

US EPA ARCHIVE DOCUMENT

# **FENAMIPHOS**

## **ENVIRONMENTAL RISK**

### **ASSESSMENT**

provided for  
SRRD

by  
EFED's Fenamiphos RED Team:

Gabe Patrick  
Angel Chiri, PhD  
Donna Randall, MS  
E. Laurence Libelo, PhD  
R. David Jones, PhD

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**ATTACHMENT 1: July 12, 2001 Memorandum: Revised Fenamiphos Estimated Environmental Concentrations**

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## C. ECOLOGICAL RISK ASSESSMENT

### Executive Summary

The Environmental Fate and Effects Division (EFED) has determined, based on a screening level risk assessment and supported by incident data, that all current uses of fenamiphos exceed all the levels of concern (LOCs) for terrestrial and aquatic wildlife defined by the Office of Pesticide Programs (OPP). Compared to other organophosphate pesticides, fenamiphos poses the highest overall risks to terrestrial and aquatic organisms for each of the crops evaluated (citrus, stone fruits, peanuts, and tobacco).<sup>1</sup> In addition, monitoring has demonstrated that fenamiphos use may result in significant concentrations in ground water near several use areas. Conservative modeling indicates that fenamiphos may contaminate surface water at high concentrations; low level residues were found in the United States Environmental Protection Agency–United States Geological Survey (EPA-USGS) pilot reservoir monitoring study, which did not target fenamiphos use areas. Jar tests voluntarily conducted by the registrant indicate that fenamiphos and fenamiphos sulfone will not be appreciably removed by conventional water treatment methods but powdered activated carbon may be effective in adsorbing fenamiphos. From 1994 to 1996, during the reregistration process, mitigation measures were implemented to reduce risks resulting from fenamiphos use. Current amended label rates and uses were used in this risk assessment.

The environmental fate and ecotoxicity databases are fairly robust and adequate to identify risks associated with fenamiphos use. Additional data for the two major degradates would be useful in refining the risk assessment but would not be expected to reduce calculated risks. Currently, substantially more monitoring data are available for ground water than for surface water. Additional monitoring could be used to further refine drinking water exposure estimates for surface water and to refine ground water estimates for specific uses and geographic areas.

### Use Characterization

Approximately 67 percent (%) of fenamiphos is used on four agricultural crops: tobacco (29%), grapes (17%), citrus (11.5%), and peanuts (9.5%). Fenamiphos is used on 25% or less of the total acreage under cultivation for any one crop. Fenamiphos use on turf (including golf courses) accounts for about 8.6% of the total pounds applied per year.

### Environmental Fate

Fenamiphos and its major degradates will be moderately persistent in soil, water, and sediment. Relevant environmental half lives for fenamiphos and its sulfoxide and sulfone degradates, excluding photolysis, range from approximately 19 to 90 days. Persistence data are incomplete for the degradates, but in soil, they appear to be at least as persistent as the parent.

Fenamiphos and its degradates will also be mobile in soil, increasing the potential for leaching into groundwater and runoff contamination of surface water. Based on laboratory and field studies, the sulfoxide and sulfone degradates are more mobile than the parent in the soil profile. Both fenamiphos sulfoxide and sulfone have been detected in groundwater in Florida and elsewhere, indicating that they are sufficiently persistent to leach in some environments.

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<sup>1</sup>

EFED Comparative Analysis of the 13 OP Pesticides in Phase 6 by Crop. D.J. Urban, May 2, 2000



Soil incorporation by watering-in or physically mixing with the soil, as specified on labels, will reduce but not eliminate fenamiphos runoff. Although fenamiphos is susceptible to rapid photodegradation to fenamiphos sulfoxide on soil (half-life 3.23 hours), only approximately the top one millimeter of soil is typically exposed to solar radiation. The rest of the chemical in the top centimeter and below will not be exposed, leaving substantial quantities of fenamiphos available for runoff for several weeks post-application.

### Surface Water Resources

Modeling of use on major crops used Tier II models (PRZM-EXAMS), with the exception of turf where concentrations were estimated using a Tier I screening model (GENEEC). Tier I screening modeling was used for all other crops. When soil incorporation was allowed for a specific use, that agronomic practice was simulated in the modeling using the minimum allowed depth of incorporation. Maximum application rates were used in modeling; however, these rates are comparable or only slightly greater than typical grower use rates for the major crops and turf (EPA/BEAD, 1995)<sup>2</sup>. Modeling results, providing reasonable upper-end concentrations for water bodies immediately downgradient of major use sites, range from 7.9 parts per billion (ppb) for peanuts to 881 ppb for turf on an acute basis and from 4.5 to 591 ppb for 60-day average concentrations. Drinking water exposure was estimated using the Index Reservoir scenario and Percent Cropped Area adjustment factors for major crops, with the exception of turf. Modeling results based on fenamiphos use on grapes, peanuts, peaches, and tobacco provide upper-bound concentrations for drinking water reservoirs downgradient of major use sites ranging from 19 ppb (peanuts) to 141 ppb (grapes).

Surface water monitoring data are very limited for fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone, in part because they are not currently regulated under the Safe Drinking Water Act. From 1999 through 2000, EPA and USGS jointly sponsored a program to monitor twelve drinking water reservoirs across the United States. Samples were analyzed for a number of pesticides, including fenamiphos and its sulfoxide and sulfone degradates. Degradates of fenamiphos were detected in three out of the twelve reservoirs at concentrations ranging from 0.005 to 0.033 ppb. Degradates were also detected in the finished water (i.e., water that has been processed for use as drinking water) at all three reservoirs at concentrations ranging from (0.007 to 0.022 ppb). Identification of fenamiphos uses, application timing, and amounts, if any, applied within the watersheds of these reservoirs have not been determined.

### Ground Water Resources

EFED reviewed available monitoring data from a variety of sources including registrant-conducted studies, USGS monitoring, and state monitoring information to estimate impacts from fenamiphos use on groundwater quality. Because a maximum contaminant level (MCL) has not been established for fenamiphos and its degradates, no monitoring is conducted under the Safe Drinking Water Act (SDWA). The two major fenamiphos use states, California and Florida, have monitored for this pesticide, but fenamiphos is also used in 27 other states where no reliable monitoring has been conducted.

Estimated environmental concentrations (EECs) were calculated, primarily using results from small scale prospective groundwater studies (PGWs), which measured impacts of a one-time application of fenamiphos on shallow ground water. Three PGWs (in Florida, Georgia, and California) were conducted on soils that are highly vulnerable to leaching and occur in fenamiphos use areas. These values represent

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<sup>2</sup>

BEAD, October 12, 1995, *Expedited Preliminary Benefit Analysis of Fenamiphos for Selected Use Sites*

reasonable estimates of the concentrations which can be expected in shallow ground water in areas where the soils, climate, use rates, agronomic practices and hydrogeology are similar. Private and small public water supply wells often derive their water from such sources. Data from Florida, for example, indicate that there are a large number of shallow wells on the Central Ridge and throughout the state.

Concentrations were estimated for a range of uses for a particular soil type based on a simple linear interpolation of the maximum application rate for the use relative to the rate applied in the PGW on similar soil. For use in very vulnerable areas, such as the Central Ridge region of Florida, EFED estimated acute groundwater EECs ranging from 43 to 435 ppb. Chronic EECs range from 4 to 45 ppb. For use on other vulnerable soils, acute EECs, extrapolated from results of the California PGW, range from 1 to 7 ppb and chronic values range from 0.1 to 0.93 ppb. Since fenamiphos may be used on a particular crop on similar soils but in areas where climatic conditions can vary, the EECs above may not be conservative. For example, the study on grapes in Fresno County, California was conducted under drier conditions than other grape growing areas, and hence one may expect greater leaching and higher fenamiphos concentrations in areas with higher rainfall. There is, however, greater uncertainty associated with concentrations estimated to occur in areas with limited or no monitoring data and for uses which were not represented by the monitoring.

Interestingly, the data from the Georgia PGW (6.6 pounds of active ingredient per acre [lb a.i./A] applied to tobacco) study do not show a pattern of movement to groundwater. These data suggest that for at least some soils fenamiphos and its degradates do not leach, but until the factors which result in limited movement at this site are defined it is not possible to extrapolate these results to other specific soils and geographical areas.

#### Toxicity and Risk to Terrestrial Organisms

Fenamiphos and its major environmental degradates (fenamiphos sulfoxide and sulfone) are rated as “very highly toxic” to most terrestrial organisms. Because of the potency of fenamiphos and its degradates, minute quantities can result in the impairment of reproductive capability or the death of wildlife. Terrestrial wildlife can be exposed to fenamiphos applied to the ground by deliberate or incidental ingestion of soil and/or granules while feeding or preening, ingestion of residues on soil invertebrates and plants, dermal contact, and inhalation. After soil incorporation, estimated fenamiphos concentrations at the soil surface exceeded OPP’s LOCs by more than 3400-fold for small animals and 68-fold for large animals. The results of the risk assessment, incident reports, and field tests support the conclusion that all current uses of fenamiphos are likely to cause mortality as well as sublethal effects to terrestrial wildlife.

Fenamiphos applied with irrigation water and uses with high application rates result in the highest expected risks. High risk is expected as a result of chemigation with low-pressure irrigation equipment using the emulsifiable fenamiphos formulation (Nemacur 3) in grape vineyards, citrus and kiwi groves and stone fruit orchards. Water used to apply fenamiphos can attract terrestrial organisms increasing the potential for exposure. High application rates associated with broadcast and banded applications of granular fenamiphos formulations (Nemacur 10 and 15% granular formulations) on turf at golf courses and turf farms and ornamental field crops pose the highest acute risks immediately after and up-to-120 hours post-application.

Wildlife deaths related to labeled granular and chemigation fenamiphos applications have been reported from use on grapes and golf courses after the implementation of risk reduction measures. Incidents of bird

deaths have occurred despite watering-in (irrigation) on turf to reduce availability of fenamiphos on the surface. One incident with birds was recorded to have occurred when drip irrigation was performed at night to reduce attraction of birds to the irrigation water. A number of field studies have been performed but their value for determining the magnitude of effects from current uses and application rates and whether mitigation measures would reduce risk is severely limited because of inadequate study design (e.g., observation time and methods, lack of cholinesterase measurements or fenamiphos tissue residues). However, they do support risk assessment results suggesting that terrestrial wildlife deaths are likely to occur at golf course, turf, citrus, grape, pineapple, and tobacco use sites. Application rates required to reduce risk to acceptable acute and chronic levels are estimated to be on the order of 0.001 lbs a.i./A; this application rate is 1,000 times lower than the current lowest application rate and 10,000 times lower than the highest application rate. This demonstrates that a large reduction in fenamiphos is required to meet OPP's LOCs.

#### Toxicity and Risk to Aquatic Organisms

Fenamiphos is rated as "very highly toxic" acutely to fish and aquatic invertebrates. Fenamiphos applied to the ground at use sites may reach surface water bodies through runoff from the site, spray drift, and contaminated groundwater/surface water interactions. The degradates, fenamiphos sulfoxide and sulfone, are equally toxic to aquatic invertebrates but are expected to be slightly less toxic to fish than fenamiphos. Because of the high toxicity of fenamiphos and its degradates only small quantities need to reach surface water to kill aquatic organisms. Estimated high-end acute and chronic surface water concentrations, from a single fenamiphos application to a use site followed by runoff to a pond three-days later (i.e., rain event), exceeded all of OPP's acute and chronic LOCs, the model included degradation rates. Estimates of chronic levels included degradation while on land and in the water. Based on these screening-level model results, fenamiphos use near surface water is expected to result in concentrations ranging from 0.8 to 93 times the median lethal concentration ( $LC_{50}$ ) for the more sensitive fresh water fish and 1.3 to 432 times the  $LC_{50}$  for the more sensitive invertebrates. Chronic risks to freshwater invertebrates is extremely high for golf course (turf), ornamental, and cotton used exceeding OPP's LOC by 48 to 142-fold. The highest acute and chronic risks for aquatic life were a result of use of fenamiphos on turf, ornamentals, and cotton.

Golf course use of fenamiphos poses high risks to aquatic organisms. The environment on and around golf courses (well drained soils, proximity to surface water) combined with the chemical characteristics of fenamiphos and its degradates (mobility, persistence, and high toxicity) results in high risk for both granular and emulsifiable fenamiphos uses. Similarly, aquatic ecosystems downgradient from high sand content soils at sites other than golf courses are likely to be highly vulnerable to acute and chronic effects.

Evidence of acute risks to fish are supported by incident reports and a freshwater mesocosm study. Since 1981, most fish kill reports have been associated with golf course uses of fenamiphos. However, in 1996 application rates to golf courses were reduced, and in the four-and-a-half years since mid-1996 only one fish incident associated with a golf course has been reported whereas in the four-and-a-half years prior to mid-1996 seven golf course related fish kills were reported. Although the reduction in golf course incidents is in part likely attributable to the reduction of application rates, one of the pre-1996 fish and bird incidents on a golf course reported an application rate of 10 lbs a.i./A, which is the current registered application rate.

A summary of fenamiphos risk quotients (RQs) for aquatic organisms is provided in Table Ex1.

**Table Ex1. Summary of Risks from Fenamiphos Application for the Major Crop Uses and Cotton, Turf, and Ornamentals**

Crop (Maximum single application rate)	Avian						Mammal						Freshwater				Estuarine /Marine
	Max. Acute RQ <sup>a, b</sup>		Acute RQ <sup>a, c</sup>	Max. Chronic RQ <sup>a, b</sup>			Max Acute RQ <sup>a, b</sup>		Acute RQ <sup>a, c</sup>	Max Chronic RQ <sup>a, b</sup>			Acute RQ <sup>a</sup>		Chronic RQ <sup>a</sup>		Acute RQ <sup>a</sup>
	Fruits, pods, seeds, & large insects <sup>d</sup>	Short grass <sup>d</sup>	Granular	Fruits, pods, seeds, & large insects <sup>d</sup>	Short grass <sup>d</sup>		Fruits, pods, seeds, & large insects <sup>d, e</sup>	Short grass <sup>d, e</sup>	Granular	Fruits, pods, seeds, & large insects <sup>d, e</sup>	Short grass <sup>d</sup>		Fish	Invert.	Fish	Invert.	Invert.
Peanuts 2.5 lbs a.i./A	1.0	16	7 to 373	20	312		0.5 to 16	39 to 249	5 to 334	16	250		0.8	4.2	1.2	55	1.3
Cotton 1.6 lbs a.i./A (granular) 3.0 lbs a.i./A (emulsifiable)	1.2	19	5 to 239	23	360		0.6 to 18	45 to 288	3 to 214	18	288		31	157	50	2,158	48
Citrus (Fl) 5 lbs a.i./A	2.0	32	--	38	600		0.9 to 30	76 to 479	--	30	480		nc	nc	nc	nc	nc
Tobacco and Grapes 6.0 lbs a.i./A	2.4	38	--	45	720		1.1 to 36	91 to 575	--	36	576		1.7 <sup>g</sup> 7.1 <sup>h</sup>	8.6 <sup>g</sup> 35 <sup>h</sup>	1.6 <sup>g</sup> 11 <sup>h</sup>	116 <sup>g</sup> 482 <sup>h</sup>	2.6 <sup>g</sup> 11 <sup>h</sup>
Citrus (non Fl) 7.5 lbs a.i./A	3.0	47	--	56	900		1.4 to 45	>113 to >718	--	45	720		nc	nc	nc	nc	nc
Pineapple 9.0 lbs a.i./A	3.6	>57	9 to 439	68	>1,080		1.7 to >77	>136 to >862	6 to 394	54	>864		nc	nc	nc	nc	nc
Ornamentals <sup>f</sup> 10 lbs a.i./A	nc	nc	34 to 3254	nc	nc		nc	nc	23 to 1525	nc	nc		86	432	103	5,183	132
Turf 10 lbs a.i./A	3.9	63	65 to 3254	74	1,188		1.9 to 59	150 to 948	44 to 2917	59.4	950		93	464	156	6,375	142

-- = Not applicable; Fl = Florida; Invert. = Invertebrate; Max = Maximum

nc = Not calculated for this use specifically, risks are bounded by the values calculated for lower and higher application rates on the table.

**All acute RQs exceed acute risk, acute restricted use, and endangered species LOCs and all chronic RQs exceed chronic LOCs.**

<sup>b</sup>RQs were calculated for four categories of food items, the ones presented here provided the low-end and high-end ranges.

<sup>c</sup>RQs were calculated for a range of body sizes from small (20 grams) to large (1000 grams); the range is provided.

<sup>d</sup>Represents exposure pathway from ingestion of residues on given food items.

<sup>e</sup>RQs were calculated for three consumption rates (15, 66, and 95% of body weight); the range is provided.

<sup>f</sup>Combination of analysis performed for two groupings: iris, lily, & narcissus; and leatherleaf fern, anthurium, & nursery stock.

<sup>g</sup>Tobacco (Although application rate is the same for grapes, typical field conditions differ which influences estimated surface water concentrations.)

<sup>h</sup>Grapes (Although application rate is the same for tobacco, typical field conditions differ which influences estimated surface water concentrations.)

## 1. Use Characterization

Fenamiphos is registered for use on: apples, asparagus, bananas (plantains), beets, brussels sprouts, cabbage, cherries, Chinese cabbage (bok choy), citrus fruits, cotton, eggplant, garlic, golf course turf, grapes, kiwi fruits, commercial/industrial lawns, nectarines, okra, ornamental and nursery stocks, peaches, peanuts, non-bell peppers, pineapples, raspberries, strawberries, and tobacco. Yearly usage of fenamiphos is about 780,000 pounds (lbs) of active ingredient (a.i.) on about 280,000 acres with 85% (663,000 lbs a.i.) of the usage on agricultural crops and 15% (117,000 lbs a.i.) on non-agricultural sites<sup>3</sup>. Approximately 80% of the agricultural usage is on four crops: tobacco (35%, 230,000 lbs a.i.), grapes (20%, 130,000 lbs a.i.), peanuts (11%, 74,000 lbs a.i.), and citrus (13.6% -- 6.7% [45,000 lbs a.i.] oranges; 3.8% [25,000 lbs a.i.] lemons; 2.3% [15,000 lbs a.i.] grapefruit; 0.8% [5,000 lbs a.i.] other). Less than 20% of the

available acreage for any given agricultural use, except pineapple, is treated with fenamiphos. Approximately 25% of the acreage under cultivation with pineapple is treated. Approximately 57% of the non-agricultural usage (67,000 lbs a.i.) is on turf (golf courses and turf farms).

Fenamiphos is formulated as either a 10% (Nemacur 10G) or 15% (Nemacur 15G) active ingredient granulated product or a 35% active ingredient emulsifiable concentrate product (Nemacur 3). The chemical profile for fenamiphos is provided in Appendix A. Nemacur 10G is primarily used on turf use sites (i.e., golf courses, lawns, and sod farms) while Nemacur 15G is primarily used on fruit, vegetables and field crops. Both granular formulations are used to control thrips and nematodes. The emulsifiable concentrate formulation is used on turf, fruits, vegetables, and field crops. Current uses and label application rates for each formulation are provided in Appendix B.

Fenamiphos is typically applied as a band or broadcast soil application preplant, at planting, or postplant prior to emergence of the crop; however, if the plants are already established, fenamiphos is applied by banding (10- to 12-inch bands) on the top of the plant row, then it is watered in with at least 0.5 inches of water. Because fenamiphos photodegrades rapidly, the label directions recommend incorporating the product below the soil surface through mechanical means or through irrigation directly after application to maintain the efficacy of the active ingredient, fenamiphos.

## 2. Integrated Environmental Fate and Ecological Risk Characterization

Whether or not terrestrial and aquatic animals will be adversely affected is dependent on the fate, distribution, and magnitude of fenamiphos in their habitat. Environmental factors can greatly modify the fate and distribution of fenamiphos. Like other chemical stressors, fenamiphos can be biotransformed by microbial communities or other environmental fate processes, which influences the degree of exposure to ecological components. Spatial and temporal distributions of ecological components must also be considered in relation to fenamiphos use. In addition, attributes of individual species must be considered such as habitat needs, food preferences, reproductive cycles, and seasonal activities.

Fenamiphos is generally applied in the Spring as a single band or broadcast soil application prior to or at planting, or postplant prior to emergence for most crop uses. Spring is the season when plants and animals reappear and reproduce—it is also when the first application of fenamiphos will most likely occur. Many terrestrial species traverse home ranges that are from several acres to several square miles in size, increasing the likelihood of exposure to pesticides during and after treatment. In addition, bird banding studies reveal that many birds return to nest in exactly the same locations every year increasing the likelihood of recurrent exposure if fenamiphos is used on the same treatment areas in subsequent years.<sup>4</sup>

If the plants are already established, fenamiphos is applied by banding (10- to 12-inch bands) on the top of the plant row, then it is watered in with at least 0.5 inches of water. Banana, plantain, pineapple, turf, citrus, strawberries, protea, anthurium, and nursery stock uses allow for additional applications through the growing season, thereby increasing the extent and magnitude of exposures to terrestrial and aquatic animals living in or adjacent to treated sites.

**Fate in Soil and Risks To Terrestrial Wildlife.** Parent fenamiphos readily photodegrades, with a half-life of 3.23 hours, when exposed to natural light on the soil surface; hence, the label directions recommend incorporating the product below the soil surface through mechanical means or through irrigation directly

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4

Ibid., p. 144.



after application to maintain the efficacy of the active ingredient, fenamiphos. Fenamiphos dissipates in the soil by microbial degradation to fenamiphos sulfoxide and sulfone followed by leaching into the soil column. Eventually, further degradation occurs via aerobic and anaerobic soil metabolism, with respective degradation half-lives of 15.7 and 87.9 days. In addition to microbial degradation, fenamiphos and its degradates may move offsite after application through runoff and/or leaching because the parent compound fenamiphos and its degradates are soluble in water.

Terrestrial wildlife can be exposed to fenamiphos applied to the ground by deliberate or incidental ingestion of treated soil and/or granules while feeding or preening, ingestion of residues on plants and soil invertebrates, dermal contact with treated soil or grass or contaminated puddles, and inhalation of mist or small particles. Because fenamiphos and its end-use formulations, NemaCur 3, 10G and 15G, are highly to very highly toxic to terrestrial vertebrates, low level exposures by dermal, inhalation or oral routes considered singly or in combination, can result in significant impairment or death of exposed individual(s). Those individuals which survive initial acute exposure will have decreased ability to escape predation due to depressed blood plasma cholinesterase levels. Individuals which survive acute exposure and predation may still experience reproductive impairment. The mammalian data submitted to EPA indicate that offspring of those individuals who survive to reproduce will have a higher potential to display developmental abnormalities in both the first (F1) and second (F2) generations. In addition, the F1 generation typically exhibits reduced body weights, depressed blood plasma cholinesterase levels and fewer surviving young. Because of the likely availability on the soil surface and within the first few centimeters and the high potential for terrestrial vertebrate exposure, broadcast applications of either the granular or emulsifiable NemaCur formulations pose the greatest acute hazard directly after and up-to-120 hours post-application. Potentially acute effects could occur greater than (>)5 days post-application depending on the application rate and method; in actual field exposure studies significant mortalities have been recorded to occur for 5 days post-application and likely would have continued but for a rain event.

Although label directions require soil incorporation by mechanical methods or by irrigation to move fenamiphos down into the soil profile, a portion of the applied fenamiphos will be available as (1) granules at the soil surface or (2) in solution as moist fenamiphos-laden soil. In addition, to adverse effects resulting from exposure to parent fenamiphos, terrestrial vertebrates may be exposed to the environmental degradates, fenamiphos sulfone and fenamiphos sulfoxide. Fenamiphos sulfone is as toxic to mammals as that of the parent fenamiphos, it is highly likely that fenamiphos sulfoxide, as indicated by desisopropyl fenamiphos sulfoxide and fenamiphos sulfone, is as equally toxic as the parent, too. Because reptiles and amphibians, in general, tend to be more acutely sensitive to manmade chemicals than birds and mammals, one can presume that fenamiphos and these two environmental degradates are very highly toxic to reptiles and amphibians as well.

***The screening level risk assessment indicates that all crop uses at current label rates and methods are expected to result in terrestrial wildlife risks exceeding acute and chronic LOCs (Section 5c).*** Expected soil concentrations, even with availability of fenamiphos reduced due to soil incorporation, exceeded acceptable risk levels by more than 3400-fold for small animals and 68-fold for large animals. Granular levels of fenamiphos in the soil are estimated to be more than 240 times higher than the level expected to kill fifty percent of exposed small birds in the laboratory (i.e., RQs are >240). The highest risks are associated with granular broadcast treatment on turf, ornamental and pineapples and emulsifiable treatment on turf, pineapple, tobacco, and citrus. Turf and tobacco field studies (Appendix C), and the incident data associated with turf use (Appendix D) support these risk conclusions. Data from several incident reports indicate that fenamiphos caused avian mortality under field conditions. In February of 1990, the USEPA

received a report with a certainty index of “highly probable”<sup>5</sup> from Martin County, Florida, about dead American Robins (*Turdus migratorius*) and Cedar Waxwings (*Bombycilla cedrorum*) linked to a fenamiphos application to turf (See Appendix D for definition of certainty index terms). Tissue sample analyses confirmed that their poisoning was the result of the fenamiphos application. In June of 1995, EPA received a report with a certainty index of “probable”<sup>6</sup> about an accidental poisoning of a Great Blue Heron (*Ardea herodias*) in relation to an application of fenamiphos to a golf course. On June 6, 1995, the EPA received a report about a family's terrier that walked across a golf course in Florida after the turf had been treated with Nemacur 3 and died.

From 1994 to 1996, during the reregistration process, mitigation measures were implemented to reduce the risks resulting from fenamiphos use. Labels were amended to incorporate new rate reductions and restrictions for many uses including turf. However, in November of 1996, EPA again received a report with a certainty index of “highly probable” from Bay County, Florida, that 28 American Coot (*Fulica americana*) were killed from exposure to fenamiphos applied to a golf course following label instructions. American Coot are slate-colored, duck-like waterfowl which inhabit ponds, lakes, marshes, and salt bays and feed on their shores and surrounding grassy areas. Additionally, one of the pre-1996 fish and bird incidents on a golf course reported an application rate of 10 lbs a.i./A, which is the current registered application rate. ***Based on these incidents and other incidents involving registered uses of Nemacur, EPA concludes that use of Nemacur on turf can cause bird kills even when the product is used in accordance with current label directions and restrictions*** (See Appendix D, Table D1).

In November of 2000, the Agency received a report with a certainty index of “highly probable” from Sonoma County, California, on a bird kill (320 birds mainly robins and bluebirds) associated with chemigation of a grape vineyard with Nemacur according to label instructions and restrictions. Fenamiphos was detected in the gullets and on feathers and feet of dead birds. The investigation was instigated by neighbors to the vineyard reporting birds dying on their lawns. After the findings in the November 2000 case, a similar grape vineyard incident of 17 dead birds reported in Mendocino County was revisited where fenamiphos had been analyzed for in the gullets but not found. An analysis of feet and feathers confirmed exposure to fenamiphos. Fenamiphos is highly toxic dermally with fenamiphos concentrations on the order of 0.02 to 0.2 milligrams of active ingredient per kilogram of body weight (mg a.i./kg-bw) causing fifty percent mortality in exposed populations

The above incidents are for acute poisoning incidents but chronic effects are also expected based on the risk characterization performed (Section 5c). Terrestrial vertebrates, whether they feed on vegetation or on other animals, are dependent directly or indirectly on plant life. Leaves, stems, twigs, bark, buds, fruits, seeds, roots, and sap of different plants all furnish wildlife with food. Next to vegetation, seeds probably constitute the major wildlife food source. Seeds make up the entire diet of some songbirds and are a segment of the diets of ducks, geese, grouse, pheasant and partridges. Of the plants growing in and around the farm field or golf course, grasses are valuable seed sources for wildlife. Fruits and flower heads of many broadleaf plants growing around the field or golf course also serve as a food source for wildlife. Therefore, terrestrial vertebrates are likely to be exposed over a long duration (chronic exposure) due to

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Requires carcass residues, substantial cholinesterase inhibition (for chemicals such as fenamiphos that depress brain and blood cholinesterase), and/or clear circumstances linking the incident to exposure to fenamiphos.

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Incidents include those where tissue residues were not available and/or exposure circumstances were less clear than for “highly probable.”

their consumption of either fenamiphos-treated plant tissues or bioconcentrated-fenamiphos levels in plants growing in treated fields. Application rates required to reduce risk to below OPP's LOCs are on the order of 0.001 lbs a.i./A; this application rate is 1,000 times lower than the current lowest application rate and 10,000 times lower than the highest application rate (Appendix H). This demonstrates that large reductions in the amount of fenamiphos applied is needed to meet LOCs.

**Endangered Animals. *Terrestrial wildlife RQs exceeded endangered species LOCs for all current uses.***

The Agency has developed a program (the "Endangered Species Protection Program") to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that will eliminate the adverse impacts. At present, the program is being implemented on an interim basis as described in a Federal Register notice (54 FR 27984-28008, July 3, 1989), and is providing information to pesticide users to help them protect these species on a voluntary basis. As currently planned, the final program will call for label modifications referring to required limitations on pesticide uses, typically as depicted in county-specific bulletins or by other site-specific mechanisms as specified by state partners. A final program, which may be altered from the interim program, will be described in a future Federal Register notice. The Agency is not imposing label modifications at this time through the RED. Rather, any requirements for product use modifications will occur in the future under the Endangered Species Protection Program. Currently available county specific information, maps and a downloadable version of the Endangered Species data base can be found on the Internet at the Agency's web site, <http://www.epa.gov/ESPP>.

**Beneficial Insects.** Parent fenamiphos is rated as highly toxic to honey bees. Since 1981, USEPA has received reports of honey bee kills from fenamiphos use. Fenamiphos is a systemic nematicide; after application it is readily absorbed by plant roots and translocated throughout the target plant. Field observations on the impacts to nontarget beneficial insects from exposure to fenamiphos end-use products applied to various orchard and field crops are summarized in Table 1.

Honey bees and other beneficial insects may have a greater potential for extended exposures via the nectar and pollen of blooming plants growing in and around treated areas. EFED has requested pollen, nectar and plant residue data on specific crops to help determine more precisely the risks to beneficial insects from the systemic effects of fenamiphos.

**Table 1. Beneficial Nontarget Insect Toxicity Findings -- Fenamiphos End-Use Formulations**

Species/Formulation	% a.i.	Rate and Method of Application	Reported Observations	MRID No. Author/Year	Study Classification
Predatory Mites (Order <i>Acarina</i> )/Nemacur 3	35	0.5 lbs a.i./100 gallons of foliar spray on apple trees	Treatments were highly toxic to 2 predatory mite species	ACC 120301/Lamb & Nelson, 1971	Supplemental
Predators Nemacur 3	35	1 lbs a.i./A on dry field beans	Treatments were highly toxic to predators	ACC 120301/Lamb & Nelson, 1971	Supplemental
Parasites and Predators/Nemacur 10G, 15G, 3	10, 15, 35	6 lbs a.i./A broadcast in potato fields	Beneficial insects were reduced in Nemacur plots, although populations were also low in untreated plots. Post-treatment population counts 1.5, 2.5 and 3 months were equal to untreated plots.	ACC 120301/Lamb & Nelson, 1971	Supplemental
Mites ( <i>Typhlodromus</i> sp.) Nemacur 3	35	1.1 and 1.7 lbs a.i./A foliar spray, 3 applications at 21-day intervals	Treatments caused 82% reduction in predatory mites.	ACC 120301/Lamb & Nelson, 1971	Supplemental



**Table 1. Beneficial Nontarget Insect Toxicity Findings -- Fenamiphos End-Use Formulations**

Species/Formulation	% a.i.	Rate and Method of Application	Reported Observations	MRID No. Author/Year	Study Classification
Domesticated Honey Bee ( <i>Apis mellifera</i> )	10, 35	5 lbs a.i./A foliar spray on alfalfa	Nemacur 10G application resulted in 7% mortality when caged bees were exposed to treatment, and 2% and 0% mortality when bees were placed in a cage with treated foliage at 3 and 24 hours post application, respectively. Nemacur 3 caused 100% mortality at all intervals tested.	ACC 120301/ Lamb & Nelson, 1971	Supplemental

**Fate and Occurrence in Surface Water and Risks to Aquatic Animals.** The typical incorporation of fenamiphos into the soil by watering-in or by physical mixing should limit the fraction available for runoff. However, relatively high application rates coupled with only moderate susceptibility to biodegradation could result in substantial quantities of fenamiphos or its degradates available for runoff for several weeks post-application. EFED has very little monitoring data on the concentrations of fenamiphos and degradates in surface water and it was not targeted to fenamiphos use areas therefore no reliable conclusions can be made from empirical monitoring data to characterize the fate of fenamiphos in surface water in use areas. Water supply systems are not required to sample and analyze for fenamiphos because it is not currently regulated under the SDWA. Because reliable monitoring data are not available, the surface water assessment of fenamiphos was based on results of Tier I modeling, which uses the Generic Estimated Environmental Concentration (GENEEC) model, and Tier II modeling, which uses Pesticide Root Zone Model (PRZM) and Exposure Analysis Modeling System (EXAMS). Modeling results indicated that use of fenamiphos on apples, citrus, cotton, and turf could have potentially significant impacts on surface water used for drinking because of hydro-geophysical characteristics of the soil in the regions where these crops are grown. Although fenamiphos is not widely used on some of these crops, the correlation between high use and detections in water resources is very tenuous and, therefore, the impact could still be significant although the use is low. The estimated acute and chronic concentrations of fenamiphos in surface water for all modeled uses are in Appendix E (Table E3). It is important to note that the modeling results represent estimates of fenamiphos parent concentrations only. The sulfoxide and sulfone degradates are reported to be at least as persistent as fenamiphos in soil but more mobile and they are also extremely toxic to aquatic invertebrates and highly toxic to fish. Consequently, they will be available for runoff at least as long as fenamiphos.

Once fenamiphos has reached an aquatic system its resistance to abiotic hydrolysis, its low potential for volatilization from surface water, and only a moderate susceptibility to biodegradation should make it persistence longer in deeper and/or unclear waters, particularly those with low microbiological activities and long hydrologic residence time. An anaerobic soil metabolism half-life of greater than 60 days indicates that it may be substantially more persistent in typically anaerobic sediment/lower water column than in the typically aerobic upper water column. The soil/water partitioning of fenamiphos indicates that its concentration in sediment pore water at equilibrium will be comparable to or somewhat lower than its concentration adsorbed to suspended and bottom sediments. Concentrations in the water column near the sediment interface should be comparable to those in sediment pore water but should decrease in the direction of the water surface.

*The screening level risk assessment indicates that for all current registered fenamiphos uses and application rates, aquatic communities (fish and invertebrates) downgradient of runoff from the*

*application site are expected to be adversely affected (Section 5d).* Concentrations estimated to occur in surface waters immediately downgradient of a use site are more than 3.5 times higher than the level which kills fifty percent of the most sensitive exposed aquatic invertebrates in the laboratory. Estimated levels for surface waters associated with turf use based on screening level aquatic exposure model are 93 times and 464 times higher than the level which kills fifty percent of the most sensitive of the tested aquatic fish and invertebrates, respectively, in the laboratory. The reported incidents associated with turf use on golf course sites and the submitted pond system study (mesocosm) support that exposed fish and invertebrates downgradient of a use site are likely to experience mortality and reproductive impairment as a result of fenamiphos runoff from treated areas. A fish kill occurred while researchers were conducting a turf field study. The kill involved more than 100 fish and was the result of a heavy rain that caused a pond to overflow onto the treated portion of the golf course. With the incident report, the registrant also submitted a paper entitled "Assessment of a New Jersey Lake Contaminated with Fenamiphos," presented by the New Jersey Department of Environmental Protection at the Third National Research Conference in Richmond, Virginia on November 8 and 9, 1990 (MRID 41012902). This paper discusses a fish kill after a golf course was treated with fenamiphos. The first two of a four lake system suffered massive fish kills (200-to-1,000 dead fish) from a Namacur 10G application to a nearby golf course before a heavy rainfall. Three-thousand and thirty-five pounds of Namacur 10G was applied over 15.9 acres of golf course (19 lbs a.i./A).

Since 1981, the United States Environmental Protection Agency (USEPA) has received numerous reports involving fish kills from fenamiphos uses. From 1990 to 1994, USEPA averaged three reports per year about massive fish kills (200-to-1,000 dead fish) resulting from granular applications of Namacur to golf courses in various counties of Florida. The majority of these reports had a certainty index of "highly probable". Since these incidents, the application rate for Namacur 10G has been reduced and certain application restrictions imposed (November 8, 1995); currently only 10 acres can be treated in a 24-hour period on United States (U.S.) golf courses, with a maximum seasonal application of 20 lbs a.i./A. Currently, the number of reported fenamiphos incidents appears to be declining, suggesting that massive fish kills caused by fenamiphos application(s) to golf courses are decreasing; but they are not disappearing. In February and June of 1996, EPA again received reports of massive fish kills associated with fenamiphos granular applications to golf courses in two counties of Florida. One incident had a certainty index of "probable" and the other a certainty index of "highly probable;" only one of the two reports appears to be associated with a misuse of Namacur 10G. Additionally, one of the pre-1996 fish and bird incidents on a golf course reported an application rate of 10 lbs a.i./A, which is the current registered application rate. ***Based on these incidents, EFED concludes that use of Namacur 10G on golf courses can cause fish kills even when the product is used in accordance with current label directions and restrictions.***

Aquatic animals also may be exposed to the environmental degradates, fenamiphos sulfone and sulfoxide from fenamiphos runoff, spray drift, and/or groundwater to surface water interactions. With the exception of acute risks to endangered and threatened species, the acute risks to freshwater fish from fenamiphos sulfone and sulfoxide exposure is low because these degradates are only moderately toxic on an acute basis; however, the acute risks to freshwater invertebrates is considerable as fenamiphos sulfoxide based on the submitted, supplemental acute toxicity study is as toxic as the parent and both are very highly toxic to aquatic invertebrates. Due to the lack of acute toxicity data on the degradate, fenamiphos sulfone, the acute risks to aquatic invertebrates cannot be determined. Similarly, the chronic risks to estuarine/marine animals and the chronic risks to freshwater animals cannot be determined due to the lack of chronic toxicity data.

**Fate and Occurrence in Groundwater.** Empirical evidence of leaching of fenamiphos and its degradates exists but it is limited since monitoring has only been conducted in six states and often not in fenamiphos use areas; no monitoring is required under the SDWA because a maximum contaminant level (MCL) has not been established for fenamiphos and its degradates. The two major fenamiphos use states, California and Florida have monitored for fenamiphos, but this pesticide is also used in 27 other states where no reliable monitoring data are available.

In 1992, the registrant agreed to conduct three prospective studies in major use areas: the Florida study began in 1995 and ended in 1996; the Georgia study on tobacco began in 1996; the California study on grapes began in October 1997, and only preliminary data have been received to date (September 2001). The preliminary data from the Georgia study do not show a pattern of movement to groundwater. However, the Agency cannot draw conclusions as to why this is the case until the additional information is submitted by the registrant.

***The California study confirms that fenamiphos and its degradates leach to groundwater.*** Fenamiphos and fenamiphos sulfone were detected in one ground-water sample, at concentrations of 0.05 and 0.53 ppb respectively. Fenamiphos sulfoxide was detected in ground water samples from four of eight well clusters, at concentrations up to 2.13 ppb. Because lapses in sampling occurred during times when potentially peak concentrations might have occurred these concentrations can be considered as a lower bound measure of the peak concentrations of total fenamiphos residues in ground water resulting from use of fenamiphos on grapes. Final conclusions about the quality of this study must be reserved pending completion of the study and review of the final data and report.

Data from monitoring in Florida confirmed that fenamiphos and its degradates leach to groundwater at high levels, based on detections of fenamiphos in the prospective study on sandy soils at a citrus use site in the Central Ridge of Florida (Dyer, D. G., et al., 1998). Total residues in one sample ranged up to 87.2 ppb. The USEPA has established an adult lifetime Health Advisory of 2 ppb for fenamiphos. It is important to note that while fenamiphos can be applied in multiple seasons over many years in a citrus grove in actual practice, this study simulated the impact of a single application on shallow groundwater. Based on results of this study fenamiphos use on citrus from the Central Ridge of Florida. USEPA requested that the registrant identify other similarly vulnerable areas and propose additional use restrictions in 1997. This study is a suitable surrogate for other areas in the Central Ridge of Florida, and provides insight into fenamiphos use in other use areas where sandy soils occur and groundwater tables are shallow, particularly in the south-east portion of the country.

An earlier retrospective monitoring study (Lenz, M.F., 1997) reflecting the impact of multiple years of fenamiphos use on Florida citrus in the Central Ridge area reported a high total residue concentration of 252.8 ppb, with maximum total residues in 4 of 6 on-site wells exceeding 65 ppb. The Agency required that a groundwater label advisory be placed on the fenamiphos label as a result of this retrospective study, and, along with the state of Florida, further required additional prospective studies be conducted to more clearly establish the relationship between use according to the label and groundwater impacts.

In California, fenamiphos is on the Groundwater Protection List, indicating that there is a concern for groundwater contamination in the State (Segawa, 1996)<sup>7</sup>. The List was created so that monitoring could be conducted for certain pesticides for which there was a groundwater concern. Groundwater monitoring

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Segawa, R. 1996. California Department of Pesticide Regulation, personal communication.

has been conducted for fenamiphos in drinking water wells in the fenamiphos use area and in other wells. To date, no fenamiphos detections have been reported. Other states including Mississippi, Oregon, Texas, and Washington have conducted some limited groundwater monitoring for fenamiphos. Results from these studies are inconclusive because fenamiphos use areas did not necessarily coincide with monitoring sites and generally only parent fenamiphos was analyzed. No residues were found in any of the wells in these states.

**Drinking Water EECs.** Public and private drinking water sources typically consist of groundwater or surface water resources. EFED has only limited surface water and groundwater monitoring data for fenamiphos and its degradates and only one drinking water study for surface water and one for groundwater, for most of these data identification of fenamiphos uses, application timing, and amounts, if any, within the immediate watershed of the surface water bodies (i.e., streams, rivers, reservoirs), or the drinking water wells have not been determined. Water supply systems are not required to sample and analyze for fenamiphos or its degradates because they are not currently regulated under the SDWA.

A number of pesticides, including fenamiphos and its major degradates, fenamiphos sulfoxide and fenamiphos sulfone, were analyzed from water supply intakes, in finished water, and at reservoir outlets of 12 reservoirs across the U.S. during 1999 to 2000. Degradates of fenamiphos were detected sporadically in water at supply intakes (range of 0.005 to 0.033 ppb) and in finished water (range 0.007 to 0.022 ppb) at 3 of the 12 reservoirs, one of the reservoirs where fenamiphos sulfone had been detected in finished water for two consecutive months during the first year of sampling was not sampled during the second year of the program. Because the pilot study was not designed to directly correlate fenamiphos use areas and loading in a watershed with concentrations in downgradient reservoirs predictions about the magnitude of fenamiphos and its degradates in drinking water for reservoirs across the nation can not be made. ***However, the results do support the conclusion that fenamiphos and/or its degradates do and may get into surface waters and subsequently will be found in drinking water in areas where the community water system is in close proximity to use areas.*** Because little surface drinking water monitoring data are available and sampling was not conducted with adequate frequency to capture peak concentrations, surface drinking water EECs for fenamiphos were based on results of Tier II modeling with the Index Reservoir Model. Concentrations of degradates were not modeled. Modeling results for a drinking water reservoir downgradient of a watershed planted in grapes are 141 ppb for the peak concentration, 13.7 ppb for the annual mean, and 7.4 ppb for the overall mean (i.e., 36-year average), the drinking water estimates were the highest of the major crops evaluated, except for cotton. Cotton had the highest drinking water EECs, however use on cotton is currently slated to be discontinued. Until such time as use on cotton is offlabeled alternative drinking water model results considering cotton and peaches grown in the same watershed in the southeastern U.S. (which is feasible) estimate peak concentrations of fenamiphos in the reservoir of 199 ppb with an annual mean of 21.6 ppb, and an overall mean of 8.3 ppb.

In California, fenamiphos is on the Groundwater Protection List, indicating that there is a concern for groundwater contamination in the State (Segawa, 1996). The List was created so that monitoring could be conducted for certain pesticides for which there was a groundwater concern. Groundwater monitoring has been conducted for fenamiphos (but not its degradates) in drinking water wells in the fenamiphos use area (40 wells in six counties in 1990 to 1991 and in 1993 to 1994) and in other wells (mid-1980's to present). To date, no fenamiphos detections have been reported, detection limits were 0.1 ppb in the drinking water wells but were 0.05 to 100 ppb in the other wells. While not drinking water wells, other groundwater monitoring studies, as described in the preceding groundwater occurrence section, provided solid evidence that fenamiphos and its degradates leach to groundwater. Available groundwater



monitoring data are somewhat limited but high quality data that is available have shown that significant groundwater contamination may occur in areas with sandy soils. Prospective and retrospective studies have found concentrations of parent fenamiphos and its degradates of up to several hundred ppb. Based on prospective groundwater studies conducted in Florida and California concentrations which can be expected to occur in groundwater as a result of normal agricultural and non-agricultural uses have been determined. For use in very vulnerable areas, such as the central ridge region of Florida, acute groundwater EECs range from 43 to 435 ppb. Chronic EECs range from 4 to 45 ppb. For use on vulnerable soils, acute EECs are estimated to range from 1 to 7 ppb and chronic values to range from 0.1 to 0.93 ppb. In less vulnerable areas leaching may be greatly reduced but the processes which may limit leaching are not well understood.

**Uncertainties in Risks, Terrestrial.** EFED's avian pesticide assessment model is intended as a screening tool; the model compares RQs (EECs divided by avian and mammalian laboratory toxicity test results) to the OPP's established criteria, LOCs. These LOCs are established such that if a pesticide meets or exceeds these criteria, a substantial question of safety exists. Existing acute and chronic LOCs were developed using the data from 36 pesticides where effects are observed to occur at specified levels.<sup>8</sup> Therefore, the screening criteria are established to account for variability, uncertainty, and to ensure that if unreasonable adverse effects are likely, these risks could be identified by the LOCs. Because the same assessment model that is used for birds is also used for wild mammals, the same underlying assumptions and uncertainties exist when extrapolating laboratory data to field conditions. However, intraspecific (within a species) extrapolations from the laboratory rodent to the wild rodent, for example, are less an issue than it is for avian laboratory to field extrapolations. Mammalian intraspecies variability is addressed by Dourson and Stara (1983) who analyzed 490 studies and compared probit log-dose slopes. From these they determined that differences due to genetic variability of test species only resulted in a intraspecies uncertainty factor of ten.

Maximum single application rates were used to calculate EECs; however, maximum application rates are not always used in the field. In circumstances where concentrations less than the maximum application rate is applied, the EECs for a single application, on a field that has not been previously treated would be overestimated and the risks would also be overestimated. However, in 1994 to 1996, application rates were reduced for a number of crops and turf in an attempt to reduce risks. Thus the current maximum application rates are more reflective of actual rates used in the field. In addition, estimates of risks made using the maximum single application rate provide an upper bound estimate of the risks which would occur when this rate is used in the field with the recognition that in reality a range of risks exists.

**Uncertainties in Exposure and Risks, Aquatic.** Aquatic exposure models estimate the upper bound concentration of pesticide possible in a pond of water without an outlet which is located next to the use site. There are several factors which limit the accuracy and precision of this analysis including the selection of scenarios most likely to result in higher concentrations of fenamiphos in runoff or small waterbodies, the quality of the input data, the ability of the models to represent the real world, and the number of years that were modeled.

Scenarios that are selected for use in Tier 2 EEC calculations are ones that are suspected to produce large concentrations in the aquatic environment. The scenario selected represents a site that really exists and

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Ecological Levels of Concern, A Comparative Analysis, Office of Pesticide Programs, USEPA, Washington, D.C., March 1995.

would be likely to have the pesticide in question applied to it but site geological and hydrological conditions and applications are extreme enough to provide conservative estimates of the EEC, but not so extreme that the model cannot properly simulate the fate and transport processes at the site. Currently, sites are chosen by best professional judgement to represent sites which generally produce EECs larger than 90% of all use sites for that crop. The EECs in this analysis are accurate only to the extent that the site represents this hypothetical high exposure site. The most limiting part of the site selection is the use of the standard pond with no outlet. Obviously, a Georgia pond, even with appropriately modified temperature data is not the most appropriate water body for use in New York. It should be remembered that while the standard pond would be expected to generate lower EECs than most water bodies. Some water bodies would likely have higher concentrations. These would be shallow water bodies near agricultural fields that receive most of their water as runoff from agricultural fields that have been substantially treated with fenamiphos.

In general, the fate data for fenamiphos are good. In particular, the quality of the aqueous photolysis data and the lack of aquatic metabolism data limit the accuracy of this analysis. Additional metabolism data would greatly increase confidence in the results, and likely reduce the EEC estimates. In particular, if aquatic metabolism data were available, it would greatly increase EFED's confidence in the water exposure assessment.

While the models are some of the best environmental fate estimation tools available, they have significant limitations in their ability to represent some processes. Spray drift is estimated as a straight 1% of the application rate reaching the pond for each application from ground application. In actuality, this value should vary with each application from zero to perhaps as high as 2 or 3%. Other limitations of the models used is the inability to handle within site variation (spatial variability), no crop growth algorithms, and an overly simple soil water transport algorithm (the "tipping bucket" method). A final limitation is that only thirty-six years of weather data was available for the analysis at both Tier II sites. Consequently there is approximately 1 chance in 20 that the true 10% exceedence EECs are larger than the maximum EEC calculated in the analysis. If the number of years of weather data could be increased it would increase the confidence that the estimated value for the 10% exceedence EEC was close to the true value.

In addition, interspecies, intraspecies, and laboratory-to-field extrapolations and presumptions on the potential concentrations in the environment rather than using actual residue data greatly increase the uncertainty factors; nevertheless, acute risks to aquatic animals were still determined to be significant.

Due to the lack of chronic toxicity and residue data, the chronic risks to aquatic environments are unknown. Life-cycle studies were not submitted; therefore, it is unknown whether or at what levels negative impacts could occur on the life-cycle of aquatic organisms when exposed to fenamiphos. The life-cycle test is designed to show reproductive and developmental effects resulting from exposure.

At this time, very limited information on the fate of the degradates in the environment has been submitted. Therefore, the calculated risk quotients for fenamiphos sulfone presume conversion rates based only on this limited information; therefore, confidence in the RQ values provided are low due to the lack of environmental fate data on the degradates.

Maximum single application rates were used to calculate EECs. The uncertainty that this adds to risk estimates are provided above under the uncertainties for risk, terrestrial.

### 3. Exposure Assessment

A summary of the fate studies performed and their results are provided in Section 3a, Environmental Fate and Transport Data. Terrestrial Exposure Assessment, Section 3b, identifies the potential routes of exposure to terrestrial wildlife and provides estimates of fenamiphos concentration in soil and terrestrial based food items from fenamiphos application uses, rates, and methods. Modeled estimates and empirical data of fenamiphos concentrations in surface water, groundwater, and drinking water are presented in the Water Resources Exposure Assessment, Section 3c.

At this time, four data requirements in the environmental fate guidelines are either not fulfilled or need to be upgraded (Table 2). However, based on the fate data that is available the Agency has sufficient data to perform a comprehensive qualitative and quantitative exposure characterization for fenamiphos. The need for additional fate and transport data is evaluated on a case-by-case basis, depending on the results of lower tier studies, intended use patterns and pertinent environmental factors.

**Table 2. Summary of Environmental Fate and Transport Data Needs.**

Guideline	Number of Tests Required	Form	Reason
161-2 Photodegradation in water	1	Fenamiphos (Should be of sufficient quality to also provide half-lives for its major degradates – fenamiphos sulfoxide and fenamiphos sulfone)	Current study unacceptable and needs to be repeated. Data on degradates are necessary because they are of toxicological concern.
Aerobic Subsoil Metabolism Study	1	Fenamiphos (Should be of sufficient quality to also provide half-lives for its major degradates – fenamiphos sulfoxide and fenamiphos sulfone)	Needed to reduce uncertainty in the fate of fenamiphos and its major degradates in subsoil and ultimately to groundwater
163-1 Batch Adsorption/Desorption	1 (4 soil types)	Fenamiphos	Current study needs to be upgraded
163-1 Batch Adsorption/Desorption	1 (Same soils as parent)	Fenamiphos sulfoxide	Needed because degradates of toxicological concern
163-1 Batch Adsorption/Desorption	1 (Same soils as parent)	Fenamiphos sulfone	
164 Field Dissipation	1	Fenamiphos	Current study needs to be upgraded

To confirm the predicted fate and magnitude of fenamiphos and its degradates to surface water and groundwater when applied to very vulnerable soils, like that on the Central Ridge region in Florida, and less vulnerable soils EFED is requesting two monitoring studies (Table 3). Prospective and retrospective studies have been performed in the past (Section 3c) but the results do not provide groundwater or surface water EECs under the current labeling rates, or for vulnerable soils in Florida other than the Central Ridge area soils, and in the case of the Central Ridge, EECs for current allowable fenamiphos uses, such as turf. To decrease uncertainty in shallow groundwater EECs in the Central Ridge in Florida for currently allowed uses on those soils and for less vulnerable soils in Florida a drinking water monitoring study of shallow wells, hydraulically connected to golf courses, in Florida is being required. The reason for the study being conducted in Florida with turf is that Florida is a major use site for fenamiphos on turf and turf has the highest application rates. A survey of concentrations in groundwater and surface water drinking resources (paired raw intake and finished water) across use states is being required to decrease uncertainty in drinking water EECs for other soil types and crops. Additionally, EFED is re-requesting that use areas

with similar vulnerable soils such as that of the Central Ridge area in Florida be identified to allow identification of use areas where contamination of groundwater may be high.

**Table 3. Summary of Groundwater and Surface Water Monitoring Data Needs.**

Guideline	Number of Tests Required	Form	Reason
Drinking water monitoring of shallow wells near Florida golf courses	~64 wells with documented hydraulic connection to use site	Total fenamiphos (parent, sulfoxide and sulfone degradates)	Document fenamiphos in shallow wells in Florida resulting from golf course use.
Groundwater and surface drinking water survey in fenamiphos use states	<500 sites	Total fenamiphos (parent sulfoxide and sulfone)	Groundwater and surface water detections of fenamiphos, mobility and persistence
Identification of use areas with vulnerable soils similar to the Central Ridge area of Florida	Not applicable	Not applicable	To identify areas where ground water contamination may be high. Originally requested in 1997

**a. Environmental Fate and Transport Data**

Fenamiphos degradation products and degradation rates attributable to hydrolysis, photolysis in water and soil, and soil metabolism in aerobic and anaerobic soils are discussed in Section 3a(1). Mobility of fenamiphos in soil is evaluated in Section 3a(2). Sections 3a(3) and 3a(4) provide laboratory volatility results and terrestrial field dissipation results, respectively. Bioaccumulation rates in fish are discussed in Section 3a(5). Water monitoring data are described in Section 3c.



## **(1) Degradation**

### **(a) Hydrolysis**

Fenamiphos appears relatively resistant to hydrolysis with reported half-lives, in buffered solutions, of 245 days at pH 5.0, 301 days at pH 7.0, and 235 days at pH 9.0 (MRID 42149302). Fenamiphos sulfoxide is the major degradate reported in the hydrolysis study, accounting for less than or equal to 9.9% of the applied radioactivity at all pH levels by day 31. However, at pH 9 samples also contained 4-(methylthio)-m-cresol (MTMC) which accounted for 5.2% of the total radioactivity by day 31.

### **(b) Photodegradation in Water**

An aqueous photolysis study was submitted, but was conducted under artificial light from a mercury arc. These lamps produce substantially more ultraviolet light than found in natural sunlight and consequently tend to overestimate photolysis rates. This study was therefore deemed unacceptable and photolysis degradates and rates in water could not be determined. The photodegradation study needs to be repeated with fenamiphos and in a manner that provides a reliable half-life estimate not only for fenamiphos but also for its major degradates, fenamiphos sulfoxide and fenamiphos sulfone.

### **(c) Photodegradation on Soil**

When exposed to natural sunlight fenamiphos photodegrades rapidly on soil, the reported half-life is 3.23 hours (MRID 40608001). The radioactive components identified from the exposed soil samples were fenamiphos sulfoxide and parent fenamiphos.

### **(d) Aerobic Soil Metabolism**

The half-life of fenamiphos in aerobic soils, applied at a rate of 13.7 parts per million (ppm) to Howe sandy loam soil, is 15.7 days (MRIDs 42149303, 41064302, and 40933701). This half-life was calculated using sampling intervals from 0-to-100 days and linear regression ( $r^2 = 0.85$ ). Fenamiphos degraded to form fenamiphos sulfoxide with the maximum concentration (51.4% of applied radioactivity) occurring on day 14 of the study. The half-life for fenamiphos sulfoxide in aerobic soil was determined to be 62 days. Fenamiphos sulfoxide was observed to degrade to fenamiphos sulfone and 4-(methylsulfonyl)-m-cresol (MTMC sulfone). The maximum concentration of fenamiphos sulfone (3.5% of applied radioactivity) and MTMC sulfone (23.5% of applied radioactivity) occurred on days 14 and 63 post-treatment, respectively, with reported half-lives of 29 days for fenamiphos sulfone and 147 days for 4-(methylsulfonyl)-m-cresol (MTMC sulfoxide) and 3-methyl-4-(methylsulfonyl)-anisole were recovered at less than 6% of the applied radioactivity. By the end of the study 34.2% of the applied radioactivity was recovered as carbon-14 radio labeled carbon dioxide ( $^{14}\text{CO}_2$ ). The proposed metabolic pathway indicated that fenamiphos transformed to the corresponding sulfoxide metabolite and further degraded to MTMC sulfone and MTMC sulfoxide.

An additional ancillary study demonstrated that the rate of fenamiphos degradation increases as temperature increases from 16 to 28 degrees centigrade ( $^{\circ}\text{C}$ ) (MRID 40524601).

To reduce uncertainty in the fate of fenamiphos and its degradates in subsurface soil and ultimately modeled groundwater concentrations, EFED is requesting a subsoil aerobic metabolism study. The study should be conducted following the Aerobic Soil Metabolism guidelines (161-2) with the exception that subsoil be used rather than topsoil and that pH and Eh of the soil be measured.

### (e) Anaerobic Soil Metabolism

Fenamiphos, applied at a rate of 13.3 ppm to a Howe sandy loam soil, was incubated for 6 days under aerobic conditions followed by 60 days incubation under anaerobic conditions (MRIDs 41286901 and 40524601). Fenamiphos declined from 36.3% of the applied amount on day 0 of anaerobic incubation (i.e., following the 6-day aerobic incubation) to  $21.8 \pm 1.9\%$  after 60 days of anaerobic incubation with a half-life of 87.9 days. The major metabolite was fenamiphos sulfoxide (maximum of 46.5% at day 6 of aerobic conditions, decreasing to 14.3% after 60 days anaerobic incubation). Other reported metabolites were fenamiphos sulfone (maximum of 0.5% on days 52 and 66), MTMC (maximum of 3.2% on day 36), MTMC sulfone (maximum of 8.7% on day 66), and 3-methyl-4-(methylsulfonyl)-anisole (<1% on day 66).

### (2) Mobility

Based on an upgradeable batch equilibrium study, fenamiphos has the potential to be relatively mobile in soils. The reported Freundlich  $K_{ads}$  values for fenamiphos in four unclassified soils ranged from 0.95 in a sandy loam soil to 3.4 in a silt loam soil with no correlation observed between organic carbon and adsorption.

Results of column leaching studies also indicated that fenamiphos was relatively mobile with 16.2 to 63.8% of applied radioactivity found in leachate. The major metabolites, fenamiphos sulfoxide and fenamiphos sulfone, were more mobile than the parent. The greatest mobility of fenamiphos and its metabolites was in the soil with the lowest cation exchange capacity and the lowest percentage of organic matter (sand soil from Indiana) whereas the lowest mobility of fenamiphos and its metabolites was in the soil with the highest cation exchange capacity and the highest percentage of organic matter (sandy loam soil from Kansas). No parent fenamiphos was found in the leachate from the sandy loam soil from Kansas. The leachate from the soil columns contained 47.2% of applied radioactivity in the sandy loam soil from California, 63.8% in the sand soil from Indiana, and 16.2% in the sandy loam soil from Kansas. Of the radioactivity found in the leachates, the majority (greater than or equal to 76%) was fenamiphos sulfoxide. (MRIDs 40547502, 40547501, 40774808, and 40774807)

Batch adsorption/desorption studies with the major soil degradates fenamiphos sulfoxide and fenamiphos sulfone are required because these degradates are of toxicological concern. The studies should be conducted with the same soils as was used for the parent batch/adsorption/desorption study.

### (3) Laboratory Volatility

When applied at a rate of 12 lbs a.i./A to a sandy loam soil, less than 0.1% of the fenamiphos volatilized after 7 days (MRID 40774810) indicating that fenamiphos does not volatilize very rapidly from soil. Therefore, volatilization is not expected to be a major route of dissipation for fenamiphos applied to the soil.

### (4) Terrestrial Field Dissipation

Two terrestrial dissipation studies, one in Chualar and one in Fresno, California (MRIDs 42149301 and 42216201), were performed on established turf plots to determine the fate of fenamiphos when it is applied to turf. At both sites, established turf plots were treated with Namacur 3 at 10 lbs a.i./A. These field studies are classified as upgradeable pending an explanation of low recoveries at one site and information on turf sampling at both sites. While these data deficiencies limit the interpretation of the data, the data is sufficient to tentatively evaluate the dissipation of fenamiphos applied to turf.

At the Chualar site the maximum concentration reported for total fenamiphos residues (i.e., sum of the parent fenamiphos and fenamiphos degradate concentrations) was 0.32 ppm (0.21 ppm as parent fenamiphos) while at the Fresno site, the maximum total residue was approximately 12.7 times higher at 4.06 ppm (parent fenamiphos was 2.67 ppm). Half-lives of the parent fenamiphos applied to turf were similar for both Chualar (16 days) and Fresno (17 days). Parent fenamiphos was not detected (detection limit of 0.01 ppm) below the 0- to 6-inch soil horizon at the Chualar site but was as far as the 18- to 24-inch soil horizon at the Fresno site. Fenamiphos sulfoxide was detected as far as the 24- to 30-inch soil horizon at the Chualar site and as far as the 30- to 36-inch soil horizon at the Fresno site. These studies confirmed the results of the laboratory leaching and adsorption/desorption studies demonstrating that the metabolites fenamiphos sulfoxide and fenamiphos sulfone are both more mobile than the parent and have a greater potential to leach in the soil. The average half-life in the field was 75 days for fenamiphos sulfoxide and 55 days for fenamiphos sulfone.

It appears that fenamiphos applied to turf dissipates in the soil by microbial degradation to fenamiphos sulfoxide and fenamiphos sulfone followed by leaching into the soil and eventual further degradation as proposed in the aerobic soil metabolism study.

No information from acceptable field dissipation studies using granular (Nemacur 15G) formulations is currently available (MRID 42149303).

To address the question of the persistence and mobility of turfgrass pesticides researchers at the University of Florida (sponsored by the U.S. Golf Association) collected samples of thatch, soil, percolate water, and grass clippings at a USGA green. For most of the organophosphate pesticides (six tested) little was removed in grass clippings and even less appeared in the percolate water with the exception of fenamiphos. These studies showed that leaching of fenamiphos degradates and, to a lesser extent the parent, greatly exceed that of all other organophosphates examined<sup>9</sup>, and that up to about 18% of the mass applied was found in leachate<sup>10</sup>. Interestingly, in periods when irrigation was restricted fenamiphos persisted and was transported through the thatch layer into the subsurface when irrigation increased.

### (5) Fish Bioaccumulation

Based on the results of the bioaccumulation studies, fenamiphos does not bioaccumulate in fish to any appreciable extent and any residues taken up by fish are quickly depurated when fish are no longer exposed to the residues. After 28 days of exposure, the average measured bioconcentration factors (BCFs = concentration in tissue/concentration in water) were 21, 61 and 98 for fillet, whole fish, and viscera, respectively. The maximum BCFs measured for fenamiphos residues were 89 for whole fish, 24 for fillet tissue, and 230 for viscera. During the 14-day depuration period, more than 95% of the accumulated <sup>14</sup>C-fenamiphos residues depurated. The primary metabolite was phenol sulfone which accounted for up to 51% of the radioactivity found in viscera tissues. Parent fenamiphos, the sulfoxide, sulfone, phenol, and phenol sulfoxide metabolites were each less than 10% of accumulated residues. (MRIDs 40274201, 40274202, and 40274203)

9

Snyder, G.H. and Cisar, J.L., 1995. Pesticide mobility and persistence in a high-sand-content green. *USGA Green Section Record* 33:15-18.

10

Snyder, G.H. and Cisar, J.L., 1993. Mobility and persistence of pesticides in a USGA-type green II. Fenamiphos and Fonofos. *International Turfgrass Society Research Journal*, 7:983-987.

## b. Terrestrial Exposure Assessment

Based on how fenamiphos is applied (Section 1), terrestrial wildlife have the potential to be exposed via the following routes:

- ingestion of residues on food items (i.e., plants and insects),
- ingestion of residues bioaccumulated within food items;
- deliberate or incidental ingestion of pesticide granules and/or treated soil when foraging or preening,
- dermal uptake via direct contact of skin with exposed granules, treated soil or grass, contaminated puddles or surface water, or chemigation water;
- ingestion of water from contaminated surface water, puddles, or dew and chemigation water.

As a screening level risk assessment, semi-quantitative measures of risk are calculated for two exposure pathways: (1) residues on food items and (2) ingestion of granules from the surface of the soil. EFED's standard screening level risk assessment approach calculates risk as a quotient which compares exposure concentration or dose of a chemical to its toxicity ( $RQ = \text{Exposure}/\text{Toxicity}$ ), detailed RQ equations are provided in Section 5 (Risk Assessment). The results of the risk screen are used to help determine what, if any, regulatory action, mitigation, or use restriction is needed on all or some of the current registered uses. Risks to terrestrial organisms from uptake of pesticides into food items, dermal contact, and ingestion of drinking water are not quantitatively evaluated in the screening risk assessment.

Estimates of fenamiphos concentrations on terrestrial food items and soil based on application rates and methods are provided in this Section, additionally the methods used to estimate these concentrations are described. Fenamiphos residues on food items and in soil are provided in Section 3b(1) and Section 3b(2), respectively.

### (1) Fenamiphos Residues from Nemacur 3 on Plants and Insects

EFED used Hoerger and Kenaga estimates (1973)<sup>11</sup>, as modified by Fletcher and other researchers (1994)<sup>12</sup>, to approximate residues *on* plants and insects for any given pesticide soil application rate. Hoerger-Kenaga categories represent preferred foods of various terrestrial vertebrates: fruits and, bud and shoot tips of leafy crops which are preferred by upland game birds; leaves and stems of leafy crops which are consumed by hares and hoofed mammals; seeds, seed pods and grasses which are consumed by rodents; and insects which are consumed by various birds, mammals, reptiles and terrestrial-phase amphibians. Hoerger-Kenaga estimates are based on residue data correlated from more than 20 pesticides on more than 60 crops and are representative of many geographic regions (7 states) and a wide array of cultural practices. Hoerger-Kenaga estimates also consider differences in vegetative yield, surface/mass ratio and interception factors.

In 1994, Fletcher, Nellessen and Pfleeger, reexamined the Hoerger-Kenaga simple linear model ( $y=Bx$ , where  $x$ =application rate in lbs a.i./A and  $y$ =pesticide residue in ppm) to determine the accuracy of the

<sup>11</sup> Hoerger, F. and E.E. Kenaga, 1972. Pesticide Residues on Plants: Correlation of Representative Data as a Basis for Estimation of their Magnitude in the Environment. In F. Coulston and F. Korte, eds., *Environmental Quality and Safety: Chemistry, Toxicology, and Technology*, Georg Thieme Publ, Stuttgart, West Germany, pp. 9-28.

<sup>12</sup> Fletcher, J.S., Nellessen, and T.G. Pfleeger, 1994. Literature Review and Evaluation of the EPA Food-chain (Kenaga) Nomogram, an Instrument for Estimating Pesticide Residues on Plants. *Environ. Tox. Chem.* 13:1383-1391.

estimated environmental concentrations (EECs). They compiled a data set of pesticide day-0 and residue-decay data involving 121 pesticides (85 insecticides, 27 herbicides, and 9 fungicides from 17 different chemical classes) on 118 species of plants. Their analyses indicated that Hoerger-Kenaga estimates need only minor modifications to be accurate which are to elevate the predictive values for forage and fruit categories from 58 to 135 ppm and from 7 to 15 ppm, respectively. Otherwise, the Hoerger-Kenaga estimates were accurate in predicting the maximum residue values after a 1 lb a.i./A application.

Modified Hoerger-Kenaga maximum and mean EECs for four food categories: (1) short grass; (2) tall grass; (3) broadleaf/forage plants, and small insects; and (4) fruits, pods, seeds, and large insects are provided in Table 4. The mean EEC values represent the arithmetic mean of values from samples collected the day of pesticide treatment (day-0) following a direct single application at a 1 lb a.i./A rate and the maximum EEC values represent the maximum concentrations measured on samples collected the day of pesticide treatment. Although not currently validated for this use, Hoerger-Kenaga estimates are employed to predict the day-0 maximum and mean residue values on exposed insects.

**Table 4. Modified Hoerger-Kenaga EEC Residues (ppm) on Food Items of Terrestrial Vertebrates<sup>1</sup>**

Food Items	Maximum Residue EECs <sup>1</sup> (ppm)	Mean Residue EECs <sup>1</sup> (ppm)
Short grass	240	85
Tall grass	110	36
Broadleaf/forage plants, and small insects	135	45
Fruits, pods, seeds, and large insects	15	7

<sup>1</sup> Maximum and mean residue EECs are based upon a 1 lb a.i./A application rate and are based on Hoerger and Kenaga (1973) as modified by Fletcher et al. (1994).

Maximum and mean residue EEC values for a pesticide application rate other than 1 lb a.i./A are calculated using the following equations:

$$\begin{aligned} \text{Maximum Residue EEC}_i (\text{ppm}) \text{ at } x \frac{(\text{lbs a.i.})}{(\text{A})} \\ = x \frac{\text{lbs a.i.}}{(\text{A})} \times \frac{\text{Maximum modified Hoerger - Kenaga EEC}_i (\text{ppm})}{1 (\text{lbs a.i.}) / 1 (\text{A})} \end{aligned} \quad \text{Equation 1}$$

$$\begin{aligned} \text{Mean Residue EEC}_i (\text{ppm}) \text{ at } x \frac{(\text{lbs a.i.})}{(\text{A})} \\ = x \frac{(\text{lbs a.i.})}{(\text{A})} \times \frac{\text{Mean modified Hoerger - Kenaga EEC}_i (\text{ppm})}{1 (\text{lbs a.i.}) / 1 (\text{A})} \end{aligned} \quad \text{Equation 2}$$

where EEC<sub>i</sub> = estimated environmental concentration for food category i



Uses and application rates that were provided for Nemacur 3 in terms other than lbs a.i./A were converted; conversion factors, assumptions, conversion equations and label rates in terms of lbs a.i./A are provided in Appendix B.

Maximum and mean residue EECs for registered uses and application rates calculated using equations 1 and 2 are provided in Appendix E. For crops where the application rate is by linear feet of row (e.g., brussel sprouts, cabbage, cotton, bok choy, eggplant, garlic, iris, lily, narcissus, non-bell peppers, okra, peanuts, strawberries, and table beets), the distance between planting rows significantly influences the amount of pesticide applied per acre; the application rate in lbs a.i./A will increase as row spacing decreases. Therefore, unless the maximum lbs a.i./A for a given use was specified on the label, EFED calculated the maximum and mean residue EECs based on standard planting practices which represent the upper bound application rate for a given use. Unless specified otherwise, the maximum residue EEC and highest mean residue EEC for a given use was used to calculate risks. A discussion of row spacings for a given use is provided in Appendix B.

## (2) Granular Fenamiphos Soil Residues

In 1966, DeWitt and other researchers performed field studies on granular pesticides that related the milligrams of a.i. per square foot (mg a.i./ft<sup>2</sup>) to the risk to birds. EFED uses this method to assess risk to birds which means the EECs for this exposure route need to also be expressed in terms of available mg a.i./ft<sup>2</sup>. The amount of granular pesticide applied to a soil can be calculated using the application rate and standard incorporation efficiency factors ( $f_{\text{efficiency}}$ ). The amount of pesticide remaining on a soil surface after application<sup>13</sup> is estimated based on standard unincorporated surface soil rates for granular-size particles ( $1-f_{\text{efficiency}}$ ); 100% for broadcast, unincorporated; 15% for banded, incorporated; and 1% for in-furrow, incorporated applications. For the Special Local Need (SLN) registration of Nemacur 15G on bananas and plantains the application rate is in grams per acre (g/A). This rate was converted into lbs/A in Appendix B (Table B2). The application method is similar to an in-furrow, incorporated soil treatment, therefore 1% of the applied granules were assumed to be unincorporated for the calculation of a soil surface EEC for application to bananas and plantains. The formulae provided below are used to calculate the maximum EECs of fenamiphos-treated soil using current maximum single application rates. Soil surface EECs are provided in Appendix E, Table E2, by use.

### Maximum Soil Surface EEC, Banded Application.

$$z \frac{(\text{mg a.i.})}{(\text{ft}^2)} = x \frac{(\text{oz of product})}{1,000 (\text{linear ft of row})} \times \frac{1}{j (\text{row bandwidth in ft})} \times \frac{23,350 (\text{mg})}{1 (\text{oz})} \times y \frac{(\text{lbs a.i.})}{1 (\text{lb of product})} \times (1 - f_{\text{efficiency}})$$

Equation 3

13

“Comparative Analysis of Acute Avian Risk from Granular Pesticides,” Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C., March, 1992.

where  $f_{\text{efficiency}}$  is the fraction of a.i. incorporated.  $f_{\text{efficiency}}$  is equal to 0.85 for banded application with mixing or light soil incorporation;  $f_{\text{efficiency}}$  is equal to 0.99 for in-furrow application with soil incorporation.

**Maximum Soil Surface EEC, Broadcast Application.**

$$z \frac{(\text{mg a.i.})}{(\text{ft}^2)} = x \frac{(\text{lbs of product})}{1 (\text{A})} \times \frac{1 (\text{A})}{43,560 (\text{ft}^2)} \times \frac{453,590 (\text{mg})}{1 (\text{lb})} \times y \frac{(\text{lbs a.i.})}{1 (\text{lb of product})} \times \left(1 - f_{\text{efficiency}}\right)$$

Equation 4

where  $f_{\text{efficiency}}$  is the fraction of a.i. incorporated.  $f_{\text{efficiency}}$  is 0 for broadcast application with no incorporation into soil.

**c. Water Resources Exposure Assessment**

This section discusses how fenamiphos may reach surface water and groundwater resources, identifies and critically evaluates existing empirical surface water and groundwater fenamiphos data for use as EECs for the risk assessment, describes modeling methods used to estimate concentrations of pesticides in surface water and drinking water (surface water scenario) for screening exposure scenarios, and identifies what values are to be used as EECs for surface water, groundwater, and drinking water. The surface water EECs are used to calculate risks to aquatic organisms for the ecological risk assessment. Although groundwater and drinking water EECs are not used in the ecological risk assessment they are discussed and calculated here to provide a complete fate and transport discussion for fenamiphos. Drinking water EECs for surface and groundwater are used in the human health risk assessment. Surface water, groundwater, and drinking water are addressed in Sections 3c(1), (2), and (3), respectively.

**(1) Surface Water**

Fenamiphos has the potential to reach surface water via spray drift and runoff. The typical incorporation of fenamiphos into the soil should limit the fraction available for runoff. However, relatively high application rates coupled with only moderate susceptibility to biodegradation can result in substantial quantities of fenamiphos, within approximately the top one centimeter, remain available for runoff for several weeks post-application (aerobic soil metabolism half-life of 16 days for fenamiphos and 62 days for fenamiphos sulfoxide). Although fenamiphos is susceptible to rapid photodegradation on soil, only approximately the top one millimeter of soil is typically exposed to solar irradiation. The rest of the chemical in the top centimeter and below will not be exposed, and is not expected to be degraded by photolytic processes.

EFED found only limited empirical data on the concentrations of fenamiphos in surface water which is not unexpected since water supply systems are not required to sample and analyze for fenamiphos because it is not currently regulated under the SDWA. Monitoring data was identified from three sources, a study in Florida (Section 3c(1)(a)), the United States Geological Survey (USGS) water monitoring database, STORET (Section 3c(1)(b)), and a pilot reservoir study (Section 3c(1)(c)). Surface water modeling methods and results are provided in Section 3c(1)(d).

**(a) Florida**

Miles and Pfeuffer (1994)<sup>14</sup> summarized the results of monitoring by multiple investigators at 27 sites in the South Florida Water Management District (SFWMD) which includes results from the region around Lake Okeechobee, the Everglades National Park, the Caloosahatchee river, and from other “Water Conservation Areas” within the SFWMD. A total of 28 sampling events were documented over a 4.5-year period. Sampling was quarterly from June 1989 through October 1990; which subsequently increased to six times per year through November 1993. The chemical analyses were done by multiple laboratories for parent fenamiphos only, with variable detection limits (range 0.2 to 1.63 ppb) with the majority in the upper range). No detections of fenamiphos were reported.

The dominant crops in the SFWMD are reported to be citrus, sugar cane, and turf. The major use of fenamiphos identified in the SFWMD is on turf (golf courses), but the report identified the turf usage estimates provided as “very crude” estimates. No characterization of the sampling locations and sample handling procedures were provided in the report other than, a statement that these were “grab samples and analysis was not completed for about two months”.

Therefore, although Florida is one of the major fenamiphos use states, the monitoring reported was not targeted to fenamiphos use and does not provide much useful information about the impact of fenamiphos use on surface-water quality. It should also be noted that, in general, monitoring data is difficult to use to estimate a maximum concentration even under the best of circumstance because sampling frequencies are usually inadequate. In the case of this monitoring in the SFWMD, quarterly or bi-monthly sampling was far too infrequent to characterize the maximum concentration that might have occurred with any degree of certainty. Since peak concentrations are expected to be of short duration, it is highly unlikely, given the nature of these monitoring data, that a peak concentration of fenamiphos would have been detected, even if the degradates had been included as analytes.

**(b) STORET**

A search of STORET (water monitoring database) resulted in a listing of 37 samples analyzed for fenamiphos from more than 20 sites in three states. Fenamiphos was not detected in any of the samples, detection limits ranged from 0.04 to 0.75 ppb. No information is provided in STORET about whether samples were taken from fenamiphos use areas. As such, it is not possible to draw reliable conclusions about fenamiphos from this monitoring data set.

**(c) Pilot Reservoir Study**

Results of the *USEPA-USGS Monitoring of Pesticides in Water Supply Reservoirs and Finished Drinking Water: A Pilot Study* have found fenamiphos or a fenamiphos degradate in 6 water samples. This study was undertaken to provide information on the concentrations of pesticides in both raw and finished water at vulnerable drinking water supplies drawing from reservoirs. Water samples were taken from both the intake and just prior to entry to the distribution system on the same day. In some cases samples were also taken at the outlet from the reservoir. Samples were taken from 12 reservoirs across the U.S. In 1999, eight of these sites were base sites where about eleven samples were taken in each year and four sites were intensive sites where 22 raw water samples were taken a year. In 2000 three of the base sites were dropped

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<sup>14</sup>

Miles and Pfeuffer. 1994. South Florida Water Management District.



leaving 5 intensive sites and 4 base sites. The list of sites and the number of each kind of sample taken are listed in Table 5.

**Table 5. Sites and number and kinds of samples taken at each site in the Pilot Reservoir Monitoring Study.**

Location	Study Duration	Number of Samples		
		Raw Water	Finished Water	Reservoir Outlet
Canyon Lake, Lake Elsinore, CA	1999	8	8	0
Eagle Creek Lake Indianapolis, IN	1999-2000	48	22	11
Lake Bruin, St. Joseph, LA	1999-2000	22	21	4
Higginsville Lake, Higginsville, MO	1999-2000	40	25	11
Tar River Res., Rocky Mount, NC	1999	10	10	1
Lake Bowen, Chesnee, SC	1999-2000	45	27	16
Lake LeRoy, LeRoy, NY	1999-2000	22	22	0
Harsha Lake, Batavia, OH	1999-2000	22	21	11
Arcadia Lake, Edmonds, OK	1999-2000	41	18	10
Blue Marsh Res, Reading, PA	1999-2000	23	23	0
Lake Mitchell, Mitchell, SD	1999-2000	22	22	9
Lake Bardwell, Waxahatchie, TX	1999	22	0	9

Information on the fenamiphos detections are in Table 6. There were three detections of fenamiphos sulfone in the Tar River Reservoir in 1999, two in the finished water, and one in the raw water. the raw water sample occurred on the same day as one of the finished samples. No sampling was conducted at this reservoir in 2000. Fenamiphos sulfoxide was detected at two different sited in 2000. Higginsville Lake had one detection and there were two detections at Eagle Creek Lake in Indiana, both on the same day. All detections were below 0.100 ppb. The parent compound was not found in any sample in the study. It is worth noting that there is some concern about the identity of the analytes in the finished samples. In some cases, compounds in quality assurance samples were lost or converted to degradate in the finished water samples during handling and storage. Consequently, the false negative rate is higher in the finished samples than in the raw samples. However, detection of compound or its degradation product in a finished sample indicates that either the parent or the degradate water in the sample at collection.

**Table 6. Fenamiphos and its degradates found water samples taken in the Pilot Reservoir Monitoring Study.**

Location	Date	Sample Type	Analyte	Concentration (ppb)
Tar River Reservoir, NC	4/28/99	finished	fenamiphos sulfone	0.016
Tar River Reservoir, NC	5/25/99	raw	fenamiphos sulfone	0.005 <sup>a</sup>
Tar River Reservoir, NC	5/25/99	finished	fenamiphos sulfone	0.007
Higginsville Lake, MO	7/19/00	raw	fenamiphos sulfoxide	0.008 <sup>a</sup>
Eagle Creek Lake, IN	7/11/00	raw	fenamiphos sulfoxide	0.033
Eagle Creek Lake	7/11/00	finished	fenamiphos sulfoxide	0.022

<sup>a</sup>Estimated value, measurement is above detection limit but below the quantitation limit.

Identification of fenamiphos uses, application timing, and amounts, if any, within the immediate watershed of the drinking water reservoir have not been determined. Because the design of the pilot study was not to directly measure a specific pesticide within its quantitatively known use areas, be that high or low, these

results would tend to support a conclusion that fenamiphos and/or its degradates do and may get into surface waters, and subsequently will be found in drinking water in areas where the community water system is in close proximity to the use area.

#### (d) Modeling Assessment

Surface water modeling was first conducted for fenamiphos in 1996 (Jones, 1996)<sup>15</sup> and consisted of a Tier I assessment for all crops and a Tier 2 assessment for five of the six major uses. For the current risk assessment, Tier I EECs were updated for three crops (leatherleaf fern, non-bell peppers, and turf), representing the highest and lowest EECs in the first assessment plus turf which is the major crop that is not currently modeled at the Tier 2 level (Attachment 1). All Tier 2 estimates were recalculated (Attachment 1) and modeling does account for soil incorporation to the minimum depth, as allowed by label. The new assessment includes estimates of fenamiphos concentrations in drinking water from a surface water resource based on the index reservoir scenario. All estimates use newer versions of PRZM, EXAMS, and GENEEC, and updated input parameters for consistency with current guidance. Updated EECs used in this risk assessment are provided in Table 7.

GENEEC 2 (EPA, 2001) is a Tier I screening model designed to estimate concentrations of a pesticide in surface water to use in ecological risk assessments. As such, it provides upper-bound concentrations that might be found in ecologically sensitive environments because of the use of a pesticide. GENEEC 2 is a single runoff event model that can account for spray drift from multiple applications. The GENEEC model was constructed to represent a 10-hectare field immediately adjacent to a 1-hectare pond, that is two meters deep with no outlet, which receives a spray drift event from each application plus one runoff event. The runoff event moves a maximum of 10% of the applied pesticide into the pond. This amount can be reduced by degradation and soil binding in the field. Spray drift is equal to 1% of the applied rate for a ground spray application. GENEEC 2 is intended only for use with ecological risk assessments.

The Food Quality Protection Act Index Reservoir Screening Tool (FIRST) (Parker, 2001)<sup>16</sup> is analogous to GENEEC 2, but is used for drinking water exposure. The scenario built into FIRST is the Index Reservoir. The Index Reservoir is described in detail in Jones et al.(2000)<sup>17</sup>.

**Table 7. Surface Water EECs**

Crop	Maximum Single Application Rate (lb a.i./A)	Maximum Seasonal Application Rate (lb a.i./A)	Model	Acute Concentration (ppb)	21-Day Concentration (ppb)	60-Day Concentration (ppb)
Non-bell Peppers (CA, GA, and PR only) <sup>a</sup>	2.0	Not Specified But Assumed 2.0	GENEEC2	88.4	76.6	59.2
Peanuts	2.5	Not Specified But Assumed 2.5	PRZM/EXAMS	7.9	6.6	4.5
Cotton	3.0	Not Always Specified But Assumed 3.0	PRZM/EXAMS	298	259	190

<sup>15</sup> Jones, R. David, Ph.D. June 1996. Memorandum: Fenamiphos Tier 2 EEC's

<sup>16</sup> Parker, R. 2001. FIRST (F)QPA (I)NDEX (R)ESERVOIR (S)CREENING (T)OOL, Version 1.0 Users Manual, Environmental Effects and Fate Division, Office of Pesticide Programs, U.S. Environmental Protection Agency.

<sup>17</sup> Jones, R. David, Jim Breithaupt, Jim Carleton, Laurence Libelo, Jim Lin, Robert Matzner, Ron Parker, William Feeland, Nelson Thurman and Ian Kennedy, 2000. *Draft Guidance for Use of the Index Reservoir and Percent Crop Area Factor in Drinking Water Assessments*. EPA/OPP Draft dated March 3, 2000.

**Table 7. Surface Water EECs**

Crop	Maximum Single Application Rate (lb a.i./A)	Maximum Seasonal Application Rate (lb a.i./A)	Model	Acute Concentration (ppb)	21-Day Concentration (ppb)	60-Day Concentration (ppb)
Tobacco	6.0	Not Specified But Assumed 6.0	PRZM/EXAMS	16.4	13.9	9.9
Grapes	6.0	6.0	PRZM/EXAMS	67.1	57.8	43.1
Peaches	7.5	7.5	PRZM/EXAMS	29.5	25.4	19.3
Turf	10.0	20.0	GENEEC	881	765	591
Leatherleaf Fern	10.0	Not Specified But Assumed 10.0	GENEEC	820	622	393

<sup>a</sup>CA = California; GA = Georgia; PR = Puerto Rico

GENEEC 2 and FIRST provides upper bounds on the concentration of pesticide that could be found in aquatic environments and drinking water, respectively, and therefore, can be appropriately used in screening calculations. If risks calculated using GENEEC or FIRST do not exceed the level of concern, then one can be reasonably confident that the risk from transport of a pesticide to surface water is negligible. However, since these Tier I screens can substantially overestimate true drinking water concentrations, it will be necessary to refine the estimates if the level of concern is exceeded. The EECs do not reflect the concentration of any fenamiphos degradates.

Because fenamiphos is used on several crops with large acreages in the U.S. and levels of concern are exceeded, Tier II PRZM/EXAMS modeling was completed for the major crops/uses (cotton, grapes, peanuts, stone fruits and tobacco), with the exception of turf. Tier II EECs were not calculated for fenamiphos application to turf because EFED does not currently have an approved Tier II turf scenario.

Nemacur 3 is registered for use on three stone fruits: cherries, nectarines, and peaches. The vast majority of nectarines grown in the U.S. are from the Central Valley of California where little rainfall occurs during the growing season, so runoff is almost nil. In addition to California, cherries tend to be grown in the northern states of Washington and Michigan. While runoff from these northern areas is anticipated to be significant, it is still expected to be less than runoff from the peach growing areas of Georgia and South Carolina where a significant portion of the U.S. peach crop is grown. Peaches were selected for evaluation to represent the high-end exposure scenario for all three stone fruits because the Tier II EECs for peaches would be expected, due to differences in regional runoff volume, to be larger than those for cherries and nectarines.

Use of fenamiphos on apples, citrus, cotton, and turf could have potentially significant impacts on surface water used for drinking because of hydrogeologic characteristics of the soil in the regions where these crops are grown. Although fenamiphos is not widely used on some of these crops, the correlation between high use and detections in water resources is very tenuous and, therefore, the impact could be high although the use is low. The estimated acute (peak) and chronic (21-day and 60-day) concentrations of fenamiphos in surface water for these crops are provided in Table E3.

## (2) Groundwater

Because of its chemical characteristics, fenamiphos and its major degradates have the potential to leach to groundwater in vulnerable areas. Groundwater monitoring studies of fenamiphos identified by EFED are listed and briefly summarized in Table 8. The information presented in Table 8 is from several sources including registrant-conducted studies, USGS monitoring, and state monitoring information. The prospective and retrospective studies conducted by the registrant, and other studies conducted by the USGS, and the State of California are of high quality. The other monitoring studies are of lesser quality, primarily because use areas did not necessarily coincide with monitoring sites. Because a MCL has not been established for fenamiphos and its degradates, no monitoring conducted under the SDWA was identified. The two major fenamiphos use states, California and Florida, have monitored for this pesticide but fenamiphos is also used in 27 other states where no reliable monitoring data are available. The most extensive groundwater monitoring studies for fenamiphos presently available have been conducted in Florida by the registrant at the request of USEPA and the State of Florida. Results of the small-scale prospective monitoring studies, small-scale retrospective monitoring studies, and the remaining general monitoring studies are briefly summarized and evaluated in Section 3c(2)(a), (b), and (c), respectively.

**Table 8. Groundwater Monitoring Data for Fenamiphos and Degradates**

Study	Well Type	Number of Wells Sampled	Minimum Detection Limit (ppb)	Number of Wells with Detections	Concentration Range (ppb)
California prospective study on grapes (1997-2000)	monitoring	16	0.006 (parent) 0.006 (sulfoxide) 0.03 (sulfone)	5	0.05 (parent) <sup>a</sup> 0.06-2.13 (sulfoxide) <sup>b</sup> 0.53 (sulfone) <sup>c</sup>
Georgia prospective study on tobacco (1996-1998)	monitoring	16	0.02 (parent) 0.04 (sulfoxide) 0.04 (sulfone)	2	0.0 (parent) 0.04-0.05 (sulfoxide) 0.0 (sulfone)
Florida prospective (1995-1996) – citrus use site (4.1 lbs a.i./A) on the Central Ridge	monitoring	16	0.1 (all analytes)	9	0.10-0.58 (parent) 0.13-83 (sulfoxide) 0.14-3.3 (sulfone)
USGS Florida golf course study (1992-1994)	monitoring/irrigation	41	0.03 (parent) 0.2 (sulfoxide) 0.1 (sulfone)	8	0.03-0.71 (parent) 0.2-0.75 (sulfoxide) 0.1 (sulfone)
Florida retrospective (1989-1992)	monitoring	12	0.1 (all analytes)	12	0.1-24 (parent) 0.2-218 (sulfoxide) 0.1-27 (sulfone)
California monitoring program (1985-1994)	drinking water	803	0.05-100 (parent) 0.05-57 (sulfoxide, sulfone)	0	none detected
Mississippi monitoring program (1989-1995)	drinking water	348	5.0 (parent)	0	none detected
Oregon monitoring program (1986-1995)	drinking water	1000 samples	0.2 (parent)	0	none detected
Texas monitoring program (1987-1988)	drinking water	188	immunoassay	0	none detected
Washington monitoring program (1988-1995)	drinking water	248	0.12-0.3 (parent)	0	none detected

<sup>a</sup>(parent) = fenamiphos

<sup>b</sup>(sulfoxide) = fenamiphos sulfoxide

<sup>c</sup>(sulfone) = fenamiphos sulfone

(a) **Small-scale Prospective Groundwater Monitoring (PGW)**

In 1992, the registrant agreed to conduct three prospective studies in major use areas (Florida, Georgia, and California). The Florida study began in 1995 and ended in 1996, the Georgia study on tobacco began in 1996 and was terminated recently and the California study on grapes began in October 1997. The Agency worked with the State of Florida to design the prospective groundwater study in that state, in accordance with OPP's requirements and requirements of Florida's Groundwater Management Plan. Data from monitoring in Florida confirmed that fenamiphos and its degradates leach to groundwater at high levels.

**Florida.** Detections of fenamiphos in this prospective study on sandy soils at a citrus use site in the Central Ridge of Florida confirmed that fenamiphos and its degradates leach to groundwater at high levels (Dyer, D. G., et al., 1998). The study tracked over a 2-year period the impact of a one-time use of Nemacur 3 on citrus, applied at an actual rate of 4.1 lbs a.i./A to the study site. Fenamiphos residues were detected in all onsite lysimeters, all nine onsite wells and all six offsite wells. Onsite residues at 489 days after treatment (DAT) were 0.16 ppb for parent, 0.18 ppb for fenamiphos sulfoxide and at 518 DAT, fenamiphos sulfone was recovered at 0.2 ppb. In the offsite wells, fenamiphos and fenamiphos sulfoxide were recovered at 0.17 ppb and 0.22 ppb, respectively at 489 DAT while fenamiphos sulfone was recovered at 1.93 ppb at 553 DAT. Maximum concentrations of fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone ranged up to 0.58, 83.31 and 3.32 ppb, respectively, in the surficial aquifer at 183 days after application (limit of quantitation was 0.1 ppb for all pesticide analytes). Total residues in one sample ranged up to 87.2 ppb. The USEPA has established an adult lifetime Health Advisory of 2 ppb for fenamiphos. As a result of this study, fenamiphos is no longer registered for use on citrus in that area. In an April, 1997 review by the Agency (EPA ref. D233970), the registrant was requested to identify other locations in the fenamiphos use area that are similarly vulnerable, but they have not done so to date (8/99).

Although fenamiphos is no longer used on citrus in the Central Ridge area of Florida (as a result of the results of this prospective study) fenamiphos is still currently labeled for use on citrus in Florida and is used on other use sites where soils are sandy and groundwater tables are shallow. Sandy soils are commonly used for agriculture and are the dominant type of soil to which nematicides are applied. The Central Ridge study is the Agency's only controlled field study investigating the impact of fenamiphos use on groundwater quality in an area overlain by sandy soils. It is a suitable surrogate for other areas where sandy soils occur and groundwater tables are shallow, for example, in the south-east portion of the country.

**Georgia.** Fenamiphos was applied on June 5, 1996 to a 5-acre tobacco plot in Dooly County, Georgia. Total soil residues (fenamiphos + sulfone + sulfoxide) on the day of application were 3.19 ppm in the 0-6 inch soil depth, or about 97% of the theoretically applied amount, based on the target application rate of 6.6 lbs a.i./A. Depth to groundwater at the site varies from approximately 27 to 32 feet below ground surface. Study results through June 2, 1998 indicate that fenamiphos and its sulfone and sulfoxide metabolites have been found only sporadically in soil-pore water and groundwater, at concentrations up to 0.2 ppb. Data indicated that rather than leaching substantially, residues were primarily retained in the upper 12 inches of soil, where detectable levels have persisted over a 2-year period.

Concentrations at 0-6 inches fluctuated, but declined to 1.04 ppm by 34 DAT, and were 0.17 ppm at 727 DAT. In the 6-12 inch depth, total residues reached a maximum of 0.29 ppm on 119 DAT, and declined to 0.07 ppm on 727 DAT. In all samples, most of the total residue was in the form of fenamiphos



sulfoxide. Total residues remaining in the top 12 inches at 362 and 727 DAT were 0.42 ppm and 0.24 ppm, respectively (or 13.2% and 7.5% of the amount applied, respectively). The importance of irrigation or rainfall to transport during the first few weeks or months after application was demonstrated in the Florida PGW study, and is a difference between the Georgia and Florida study designs. Persistence of residues for the duration seen in the Georgia study implies that in the absence of leaching, fenamiphos residues can accumulate in the soil column over years of repeated applications.

**California.** A PGW study on grapes in California was begun in October, 1997, and preliminary information and monitoring results have been submitted in interim and progress reports. A more detailed review of the study will be done once it is complete and the final quality assurance review of the data has been submitted. The data from the progress reports is summarized here but should be considered preliminary.

This study provides potentially useful information on the leaching on parent fenamiphos and its degradates to groundwater after application to grapes in California. There are however a number of factors which limit the usefulness of the study in terms of providing an estimate of the maximum concentrations which may occur. The values that actually occur may be significantly higher than those observed in this study, and the concentrations observed should be considered low end of the maximum values that may result from use on grapes.

Typically (80% of the time), fenamiphos is applied in the spring (March - May 1); 20% of applications are in the fall (9/15 - 10/31). In this study the application, at 6 lbs a.i./A, was on October 15, 1997. The registrant has not provided a detailed explanation of how this may have affected the results. Multiple samples were not collected in the initial phase of the study from lysimeters or in a later critical phase of the study when concentrations appear to peak. A gap of 70 days occurred between ground water samples collected at the time that peak concentrations of fenamiphos sulfoxide were measured on day 302 and the subsequent sample which was collected on day 372. Soil analyses were not performed for fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone on days 14 and 29. There is no explanation provided for these important missing data. Due to the timing of missing data, peak concentrations could have occurred in several of these missed samples.

Interim reports indicate that fenamiphos and its sulfone and sulfoxide degradates were found in soil-pore water and ground water. Fenamiphos was detected in soil-pore water samples at the six foot depth from 118-394 DAT, at concentrations which ranged from 0.11 to 0.60 ppb. Fenamiphos was also detected in one lysimeter at the three foot depth on 156 DAT at a concentration of 0.1 ppb, and in two lysimeters at the nine foot depth on 370 DAT, at concentrations of 0.017 and 0.067 ppb. Fenamiphos sulfoxide was detected in soil-pore water on all sampling dates post-application (9-671 DAT). Detections occurred at the six foot depth at concentrations up to 315.1 ppb, at the three foot depth at concentrations up to 62.3 ppb, at the nine foot depth at concentrations up to 4.7 ppb, and at the twelve foot depth at concentrations up to 0.16 ppb. Fenamiphos sulfone was detected in soil-pore water at the six foot depth from day 118 to 608 after treatment. Concentrations ranged up to 31.6 ppb at the 6 foot depth, up to 11.9 ppb at the 3 foot depth, up to 0.52 ppb at the 9 foot depth, and up to 1.74 ppb at the twelve foot depth.

Fenamiphos and fenamiphos sulfone were detected in one ground-water sample, at concentrations of 0.05 and 0.53 ppb respectively, on DAT 216. Fenamiphos sulfoxide was detected in ground water samples from four of eight well clusters, at concentrations up to 2.13 ppb. As mentioned earlier, fenamiphos sulfoxide was apparently not sampled or analyzed for 70 days after the peak detection. No explanation for the failure to collect monthly samples was provided. Given that no sample was collected or analyzed

in the month following the peak concentration of 2.13 ppb, one cannot conclude that this was the peak concentration that occurred at the site, only that it was the peak concentration reported at this site. This concentration can be considered as a lower bound measure of the peak concentrations of total fenamiphos residues in ground water resulting from use of fenamiphos on grapes. Final conclusions about the quality of this study must be reserved pending completion of the study and review of the final data and report.

### (b) Small-scale Retrospective Groundwater Monitoring

A retrospective monitoring study (Lenz, 1997) conducted in 1989, before the Florida prospective study, documents the impact of multiple years of fenamiphos use on Florida citrus results, with a high total residue concentration (252.8 ppb). The Agency required that a groundwater label advisory be placed on the fenamiphos label as a result of this retrospective study, and along with the State of Florida, further required additional prospective studies be conducted to more clearly establish the relationship between use according to the label and groundwater quality.

In 1989, a small-scale retrospective study was requested by the State of Florida to support the registration of fenamiphos on citrus. The retrospective study was conducted by the registrant in Lake Placid, FL using Nemacur 3 at a rate of 9.9 lbs a.i./A in three separate applications from 1990 to 1992. Fenamiphos had been applied annually to the grove at a rate of 3.0 - 4.5 lbs a.i./A from 1985 to 1989. Twelve monitoring wells were installed at the 10-acre test site: six on-site and six down-gradient and off the treated site. The highest concentrations in the retrospective study were measured in the six wells located on the treated site, although fenamiphos and/or its two degradates were found in all wells monitored. The maximum concentrations of total fenamiphos reported in each of the six wells located on the treated site were: 142, 65.5, 10.5, 2.7, 252.8, and 94.7 ppb.

### (c) General Monitoring Studies

EFED identified other groundwater monitoring studies in Florida in addition to the retrospective and prospective studies performed in that state. Other states including Mississippi, Oregon, Texas, and Washington have done some limited ground-water monitoring for fenamiphos. Except for the Florida and California studies, results from these other studies are inconclusive because fenamiphos use areas did not necessarily coincide with monitoring sites and generally only parent fenamiphos was analyzed. No residues were reported in any of the wells in these states.

**Florida.** Fenamiphos residues were detected in groundwater on five out of seven golf courses in a study conducted by the USGS. Soils varied from fine sands with good drainage (citrus-growing soils) to Flatwoods soils with poor drainage. Maximum concentrations in groundwater were 0.71, 0.75, and 0.10 ppb for fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone, respectively (higher concentrations were found in the poorly-drained soils; Swancar, 1996)<sup>18</sup>. Groundwater here would not be used for drinking water but persistent contaminants (such as the fenamiphos degradates) could eventually find their way into drinking water supplies.

**California.** Fenamiphos is on California's Groundwater Protection List (Segawa, 1996). The List was created so that monitoring could be conducted for certain pesticides for which there was a groundwater concern. Samples were collected from 40 drinking water wells in six counties in the fenamiphos use area

<sup>18</sup>

Swancar, A., 1996. *Water quality, pesticide occurrence, and effects of irrigation with reclaimed water at golf courses in Florida*. U.S. Geological Survey Water Resources Investigations Report 95-4250. U. S. Geological Survey, Tallahassee, FL. USA. 86 p.

in 1990 to 1991 and 1993 to 1994. Using a detection limit of 0.1 ppb, no fenamiphos residues were detected. Other monitoring has been conducted from the mid-1980s to the present. No detections were seen in any of these wells; detection limits varied from 0.05 to 100 ppb.

**Mississippi.** A statewide ground-water monitoring survey was designed to sample for pesticides in major crops such as cotton and soybeans. Fenamiphos is not widely used in the State and the primary fenamiphos use crops are turf and ornamentals (Barnett, 1996)<sup>19</sup>. Almost all of the reported monitoring has been conducted in areas where fenamiphos has not been used. To date, 348 wells have been sampled and analyzed for fenamiphos and its degradates. No residues have been detected at a detection limit of 5.0 ppb for the parent.

**Oregon.** Since 1986, approximately 1,000 ground-water samples from public and private wells have been analyzed for parent fenamiphos only. Based on a 0.2 ppb detection limit, no residues have been found (McLaughlin, 1996)<sup>20</sup>.

**Texas.** From 1987 to 1988, 188 rural wells in eight counties were sampled. The analyses were made using an immunoassay screen for organophosphates including fenamiphos, no organophosphates were detected. Wells may have been near fenamiphos use areas in some counties but this cannot be confirmed (O'Hare, 1996)<sup>21</sup>.

**Washington.** Since 1988, 248 private drinking water wells in eight study areas have been sampled. Using a detection limit that varied from 0.12 to 0.3 ppb, samples were analyzed for parent fenamiphos only. No parent residues have been detected but it is not known whether there is any connection between the sampled wells and the fenamiphos use area (Erickson, 1996)<sup>22</sup>.

### (3) Drinking Water

Concentrations of fenamiphos and its degradates in the nation's drinking water resources are discussed in this Section. Because fenamiphos and its degradates are not regulated under the SDWA, there is little data available to characterize the temporal and spatial magnitude and distribution of fenamiphos and its degradates in the nation's water. Therefore, ancillary surface water and groundwater data and/or modeling results are used to provide insights into the potential fate and distribution of fenamiphos and its degradates in the nation's drinking water resources.

#### (a) Surface Water

**SFWMD Study.** It is not possible to derive reliable conclusions about the distribution and magnitude of fenamiphos and its degradates in the nation's drinking water from available surface water monitoring data in the SFWMD. Sampling was too infrequent, sample locations were not characterized overall or with respect to documented fenamiphos use, analytical method detection limits were too high, and degradates were not analyzed. A more detailed summary of this study is provided in Section 3(1)(a).

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<sup>19</sup> Barnett, Bill. 1996. Mississippi Department of Environmental Quality, personal communication.

<sup>20</sup> McLaughlin, Mark. 1996. Oregon Department of Environmental Quality, Water Quality Division, personal communication.

<sup>21</sup> O'Hare, Jeannette. 1996. Texas Natural Resources Commission, personal communication.

<sup>22</sup> Erickson, Dennis. 1996. Washington State Department of Ecology, personal communication.



**STORET.** A STORET search resulted in a listing of 37 samples analyzed for fenamiphos over 20 sites in three states. Fenamiphos was not detected in any of the samples at detection limits ranging from 0.04 to 0.75 ppb. No information is provided in STORET about whether samples were taken from fenamiphos use areas, and it is not possible to draw reliable conclusions from these data about the temporal and spatial distribution of fenamiphos and its degradates in surface waters serving as the nation's drinking water resources.

**Tier II Modeling.** EECs for use in the drinking water assessment were derived from Tier 2 drinking water modeling (PRZM-EXAMS) using the Index Reservoir scenario, and by considering the maximum percent of a watershed that could be planted in any one crop. The largest fraction of a watershed that can be planted in any one crop is called the percent cropped area factor or PCA. OPP has derived four PCAs for major crops: corn, cotton, soybeans, and wheat (Effland *et al.*, 1999). The EECs from the Index Reservoir, which assume the entire watershed is planted with treated crop, are multiplied by a PCA to adjust the results to represent a more realistic fraction of the watershed being planted. A default PCA of 0.87 is used for crops that do not have a calculated PCA. This default value reflects the maximum fraction of a watershed that may be used for agriculture in the US.

Recommended drinking water exposure values in a July 12, 2001 memo from EFED to SRRD (Attachment 1) were based on conservative modeling of fenamiphos on cotton combined with expected levels from other crops that may be grown in watersheds with cotton. Final drinking water EECs in the July 12, 2001 memo (Attachment 1) were based on combining cotton and peach EECs (Table 9). Details of the modeling, model parameters, and PCAs are provided in Attachment 1. Although fenamiphos use on cotton is going to be discontinued, EFED recommends that while existing labels allowing cotton applications are still available, the estimated values associated with cotton use should still be considered in human health risk assessments.

Alternative drinking water exposure values, ignoring cotton use, have been derived based on grapes, the crop producing the second highest reservoir EECs after cotton (Attachment 1, Table 14). Drinking water exposure values for grapes are provided in Table 9. The PCA used for grapes was the default value of 0.87 since there is no PCA for this crop. It is conservative to assume 87% of a watershed is used for grape agriculture, however, this assumption accounts for the possibility that other crops in the same watershed may also receive fenamiphos applications. The EECs are expected to be conservative and represent reasonable worst-case concentrations at a single vulnerable site. Actual measured fenamiphos concentrations in reservoirs are expected to be less than the calculated EECs because most watersheds would produce less runoff due to soil and meteorological differences and lower aquatic fenamiphos loading due to lower usage in the watershed. Details of the drinking water model, model parameters, and PCAs are provided in Attachment 1.

**Table 9 . Reservoir Drinking Water EECs**

Crop	Peak (ppb)	Annual Mean (ppb)	Overall Mean (ppb)
Cotton and Peaches <sup>a</sup>	199	21.6	8.3
Grapes <sup>b</sup>	141	13.7	7.4

<sup>a</sup>From Attachment 1, Table 1 where the OPP PCA for cotton (0.20) and the difference between the default value, 0.87, and cotton PCA was used for peaches (0.67). Although fenamiphos use on cotton is going to be discontinued, EFED recommends that while existing labels allowing cotton applications are still available, the estimated values associated with cotton use should be used.

<sup>b</sup>Uses reservoir surface water EECs from Attachment 1, Table 14 multiplied by the default PCA value of 0.87. Drinking water EEC if cotton is not to be considered.

**Pilot Reservoir Study.** Water samples were taken and analyzed for fenamiphos, fenamiphos sulfone, and fenamiphos sulfoxide from 12 reservoirs across the U.S. from 1999 through 2000. A total of three hundred and twenty-five samples were collected at drinking water intakes at the reservoirs, 82 samples were collected at reservoir outlet locations, and 319 samples of finished water (i.e., processed water ready for drinking) were collected. There were three detections of fenamiphos sulfone in the Tar River Reservoir in 1999, two in the finished water (0.007 and 0.016 ppb), and one in the raw water (0.005), the raw water sample occurred on the same day as one of the finished samples. No sampling was conducted at this reservoir in 2000. In 2000, Higginsville Lake in Missouri and Eagle Creek Lake in Indiana each had one detection of fenamiphos sulfoxide in the intake water (0.008 and 0.033 ppb). Fenamiphos sulfoxide was also detected in the finished water at Eagle Creek Lake (0.022 ppb) on the same day it was detected in the intake water. The parent compound was not found in any sample in the study. It is worth noting that there is some concern about the identity of the analytes in the finished samples. However, based on quality assurance results detection of a compound or its degradation product in a finished sample indicates that either the parent or the degradates are in the sample at collection. Identification of fenamiphos uses, application timing, and amounts, if any, within the immediate watershed of the drinking water reservoirs have not been determined. Because the design of the pilot study was not to directly measure a specific pesticide within its quantitatively known use areas, be that high or low, these results would tend to support a conclusion that fenamiphos and/or its degradates do and may get into surface waters, and subsequently will be found in drinking water in areas where the community water system is in close proximity to the use area.

## (b) Groundwater

Groundwater monitoring data available to the Agency for fenamiphos are not extensive. The two major use states, California and Florida have monitored for this pesticide but fenamiphos is also used in 27 other states where little or no monitoring data are available.

Use of fenamiphos in most states is relatively low and does not exceed about 4,400 lbs/county. Use in certain counties of California, Florida, Virginia, Georgia, and Alabama can be as high as 96,000 lbs/county (Miles, 1994). In one high-use county of Florida (Highlands County), fenamiphos and its degradates leached to groundwater at high concentrations in both prospective and retrospective studies. The acute concentrations reported in that prospective study (0.6 ppb, 3.3 ppb, and 83.3 ppb for parent fenamiphos, fenamiphos sulfone, and fenamiphos sulfoxide, respectively) are the highest levels seen in any Florida wells. Total fenamiphos residues reached 87.2 ppb in monitoring wells located on the treated site. Fenamiphos is also used in vulnerable areas in the south-east, in Suffolk County, New York, and in parts of the Delmarva peninsula (Delaware, Maryland, Virginia). In these regions, where hydrogeologic and/or environmental conditions are similar to those on the Central Ridge of Florida, fenamiphos residues may also leach to groundwater at levels similar to those seen in Florida. For this reason, the residue levels seen in Florida are used in this assessment even though the use there has been discontinued. Fenamiphos residues also moved in groundwater laterally at least 100 feet from the test site. As a result of these studies, fenamiphos is no longer used for citrus on the Central Ridge of Florida.

EFED has calculated EECs for groundwater resulting from use of fenamiphos on crops and non-agricultural uses<sup>23</sup>. EECs for agricultural and non-agricultural uses in vulnerable and very vulnerable use areas are presented in Table 10. For use in very vulnerable areas, such as the central ridge region of Florida, acute groundwater EECs range from 43 to 435 ppb. Chronic EECs range from 4 to 45 ppb. For use on other vulnerable soils, acute EECs range from 1 to 7 ppb and chronic values range from 0.1 to 0.93 ppb.

**Table 10. Drinking Water EECs For Groundwater Resources**

Crop	Maximum Application Allowed on Label (lbs a.i./A/year)	Florida Central Ridge Soils		Type A Soil	
		Acute (ppb)	Chronic (ppb)	Acute (ppb)	Chronic (ppb)
Citrus (FL PGW study measured values)	4.1 (actual application rate)	87.2	9.2	--	--
Grapes (CA PGW study measured values)	6 (actual application rate)	--	--	2.1	0.28
Citrus	7.5	160	17	2.63	0.35
Citrus (FL)	10	213	22	3.50	0.47
Grapes/Raspberry	6	128	13	2.10	0.28
Peanuts	7.5	160	17	2.63	0.35
Cotton	16	340	36	5.60	0.75
Pineapple	24	510	54	8.40	1.12
Protea/Anthurium/nursery stock	20	425	45	7.00	0.93
Iris/Lily/Narcissus/leather leaf fern	10	213	22	3.50	0.47
Bananas and plantains	6.7	142	15	2.35	0.31

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Memo from Laurence Libelo to Betty Shackelford dated 9/21/01 (Attachment 2)

**Table 10. Drinking Water EECs For Groundwater Resources**

Crop	Maximum Application Allowed on Label (lbs a.i./A/year)	Florida Central Ridge Soils		Type A Soil	
		Acute (ppb)	Chronic (ppb)	Acute (ppb)	Chronic (ppb)
Beets	3.1	66	7	1.09	0.14
Eggplant/non-bell peppers/asparagus	2	43	4	0.70	0.09
Cabbage and brussel sprouts	4.5	96	10	1.58	0.21
Strawberries	7.5	160	17	2.63	0.35
Garlic/okra	4.5	96	10	1.58	0.21
Tobacco	7.5	160	17	2.63	0.35
Apples/Cherries/Peaches	7.5	160	17	2.63	0.35
Turf/Golf courses	20	425	45	7.00	0.93

EECs have been calculated, primarily using results from small scale PGWs, for use in areas with very vulnerable soils and vulnerable soils. Very vulnerable soils are defined as those having characteristics similar to those in Central Ridge region in Florida<sup>24</sup>, and vulnerable soils as sandy, hydraulic soils group A soils. For uses in very vulnerable areas EEC values were derived using the results of a Prospective Groundwater Study conducted by the registrant in Highland County, Florida, supported by data from other, retrospective, monitoring. For less vulnerable soils the EECs were calculated using the results of a PGW study conducted by the registrant in Fresno County, California.

Acute EECs were determined from the studies as the peak total residue (parent and degradate) concentration observed in any well sample. Chronic values were calculated from the maximum 90 day mean concentration during the study. For other use areas and application rates EECs were calculated by assuming a linear relationship between application rate and groundwater concentration. The Florida and California EECs were multiplied by the ratio of application rate used in the studies to the maximum allowable rate on the label:

$$EEC = (\text{maximum allowed label rate/actual application rate in PGW}) \times (EEC \text{ determined in study})$$

In the Florida PGW study the acute and chronic EECs were 87.2 and 9.2 ppb for an application on citrus at 4.1 lbs a.i./A/year. In the California PGW study acute and chronic EECs were 2.1 and 0.28 ppb for an application on grapes of 6 lbs a.i./A/year. As shown in Table 8 the calculated acute in very vulnerable areas range from 43 to 435 ppb and chronic EECs range from 4 to 45 ppb. For use on other vulnerable soils acute EECs range from 1 to 7 ppb and chronic values range from 0.1 to 0.93 ppb.

The calculated values represent reasonable estimates of the concentrations which can be expected in groundwater. Acute concentrations were calculated using maximum concentrations observed in monitoring studies where the water table is relatively shallow (about 30 feet) and maximum allowable application rates. Concentrations were estimated for a range of uses for a particular soil type based on a simple linear interpolation of the maximum application rate for the use relative to the rate applied in the Prospective Groundwater Study. However, since fenamiphos may be used on a particular crop on similar soils but in areas where environmental conditions can vary, the EEC may not be conservative. For example, the study

<sup>24</sup>

Described as hydrologic group (HSG) A soils that are excessively drained, have low shrink/swell potential and have textures that are predominantly sand and fine sand and where the water table is less than fifty feet below the surface. See memo from Robert Matzner to Todd Peterson dated July 11, 2000 (Attachment 3)

on grapes in Fresno County, California was conducted under drier conditions than other grape growing areas, and hence one may expect greater leaching and higher fenamiphos concentrations in those areas.

Because of its chemical characteristics fenamiphos and its major degradates have the potential to leach to groundwater in vulnerable areas. Groundwater monitoring studies of fenamiphos identified by EFED are discussed elsewhere in this document and are briefly summarized in Table 8. The information presented is from several sources including registrant-conducted studies, USGS monitoring, and state monitoring information. The prospective and retrospective studies conducted by the registrant and other studies conducted by the USGS and the State of California are of high quality. The other monitoring studies are of lesser quality, primarily because use areas did not necessarily coincide with monitoring sites. Because a MCL has not been established for fenamiphos and its degradates, no monitoring is conducted under the SDWA. The two major fenamiphos use states, California and Florida, have monitored for this pesticide, but fenamiphos is also used in 27 other states where no reliable monitoring data are available. The most extensive groundwater monitoring studies for fenamiphos presently available have been conducted in Florida by the registrant at the request of USEPA and the State of Florida. EECs for use in evaluating risk from drinking groundwater which may be contaminated were primarily derived using PGW results along with results of the small-scale retrospective monitoring studies and general monitoring studies. Fenamiphos and its degradation products have been shown to leach to groundwater from agricultural and non-agricultural use sites. While the weight of evidence indicate that parent and degradates readily leach it is difficult to estimate the concentrations that will occur, and to determine EECs for use in areas with limited or no monitoring data. A national assessment of groundwater contamination based on data from a limited number of areas will include uncertainties resulting from extrapolation and required assumptions.

Without additional targeted monitoring data it is difficult to verify how accurate this approach is in estimating actual concentrations which may occur. In one case where quality monitoring data coupled with use information exists (the Florida retrospective study) a comparison of predicted and measured values is possible. In this study, with application at close to the maximum allowed rate, the maximum observed total residue concentration was 218 while the calculated value for Florida citrus on central ridge like soils is 213. This suggests that this approach is not unreasonable.

**Leaching in less vulnerable areas.** Without a better understanding of the interactions of fenamiphos and its degradation products with non-sandy soils it is not possible to predict the concentrations which may occur in areas with less vulnerable soils. The Georgia PGW study and other monitoring data suggest that in some soils fenamiphos and its degradates do not leach to groundwater to a significant extent. Based on the data that are available it is not possible to determine where these soils may be. The registrant has been requested to provide detailed information on what properties of the soil and meteorological conditions at the Georgia site resulted in restricted movement of the compounds. Until this is available it is not possible to use the results of the Georgia study to extrapolate to other areas. At this time EFED is not able to provide EECs for less vulnerable soils (type B, C and D).

#### **4. Toxicological Assessment**

The toxicity test values (i.e., measurement endpoints) to be used in the Risk Assessment (Section 5) are derived from the results of required avian, mammalian, and aquatic organism toxicity studies. Descriptions of the required toxicity studies are provided in this Section. Terrestrial organism toxicity studies are discussed in Section 4a and the aquatic organism toxicity studies are discussed in Section 4b. EFED, after a critical review process, identifies studies as either “core” (meets guideline requirements),



“supplemental” (scientifically sound but does not meet a guideline requirement) or “invalid” (scientifically unsound). Studies classified as “invalid” are not used to assess the toxicity of fenamiphos.

The need for additional toxicity data (i.e., degradates, end-use formulations, plants, higher tiered toxicity studies, etc. ) is evaluated on a case-by-case basis, depending on the results of lower tier studies, intended use patterns and pertinent environmental factors. Additional toxicity studies that EFED requires for fenamiphos are summarized in Table 11.

**Table 11. Summary of Toxicity Study Data Needs**

Guideline	Number of Tests Required	Form	Reason
71-1(A) Acute Avian Oral	1	Fenamiphos sulfoxide	Required when parent material is short-lived and a large percentage of the degradate is formed which occurs with fenamiphos.
71-1(A) Acute Avian Oral	1	Fenamiphos sulfone	
71-2(A) Avian Subacute Dietary	2	Fenamiphos sulfoxide	Required when parent material is short-lived and a large percentage of the degradate is formed which occurs with fenamiphos.
71-2(A) Avian Subacute Dietary	2	Fenamiphos sulfone	
71-4(A) Avian Reproduction	2	Fenamiphos sulfoxide	Reserved pending results of 71-1(A) and 71-2(A) results with fenamiphos sulfoxide and fenamiphos sulfone.
71-4(A) Avian Reproduction	2	Fenamiphos sulfone	
Dermal Avian Study	2	Nemacur 3 (end-use product)	Incidental data indicating deaths from dermal exposure.
141-2 Honey Bee Residue Study	1	Nemacur 3 (end-use product)	Required when exposures are anticipated which they are for banded and broadcast treatments for its fruit and vegetable crop uses.
Residue Study (nectar, pollen, and plant tissue of cherry, peach, orange, strawberry, cotton, banana and peanut plants)	1	Fenamiphos and its degradates	Required because fenamiphos is a systemic pesticide and will be translocated post-application throughout the plant and it and/or its degradates are suspected to be persistent.
122-1 Seedling Emergence – Tier I	1 (6 species tested)	Fenamiphos sulfoxide	Required because of fenamiphos’ terrestrial outdoor use pattern , its ability to move offsite in both surface and groundwater, and its labeled phytotoxicity warnings. Because of the phytotoxicity warnings fenamiphos testing should begin with Tier II testing but the degradates should begin with Tier I testing.
122-1 Seedling Emergence – Tier I	1 (6 species tested)	Fenamiphos sulfone	
122-1 Vegetative Vigor Trials – Tier I	1 ( 6 species tested)	Fenamiphos sulfoxide	
122-1 Vegetative Vigor Trials – Tier I	1 ( 6 species tested)	Fenamiphos sulfone	
123-1 Seedling Emergence – Tier II	1 (6 species tested)	Fenamiphos	
123-1 Vegetative Vigor Trials – Tier II	1 (6 species tested)	Fenamiphos	
72-2 Acute Aquatic Invertebrate, Freshwater	1	Fenamiphos sulfoxide	Raw data to upgrade current test from supplemental to core, otherwise test needs to be repeated.
72-2 Acute Aquatic Invertebrate, Freshwater	1	Fenamiphos sulfone	Required because fenamiphos degrades rapidly on the soil surface, the degradates may reach surface water through runoff.
72-4 Fish Early Life-Stage, Freshwater	1	Fenamiphos sulfoxide	Required because in surface soil fenamiphos degrades rapidly, once in water fenamiphos and its degradates are persistent (hydrolysis half-life >234 days).
72-4 Fish Early Life-Stage, Freshwater	1	Fenamiphos sulfone	
72-5 Fish Chronic Life Cycle, Freshwater	1	Fenamiphos	Required because results of early life-stage toxicity tests indicate that fish reproductive physiology may be affected by fenamiphos exposure and the estimated environmental concentration is greater than 0.1 times the early life-stage no observable effect concentration (NOEC).

**Table 11. Summary of Toxicity Study Data Needs**

Guideline	Number of Tests Required	Form	Reason
72-3 Acute Estuarine/Marine Aquatic Animals	3	Fenamiphos sulfoxide	Required because these degradates have been identified as major degradates of fenamiphos and are mobile.
72-3 Acute Estuarine/Marine Aquatic Animals	3	Fenamiphos sulfone	
72-4 Fish Early Life-Stage, Estuarine/Marine	1	Fenamiphos	Required because end-use formulation is expected to be transported from the intended use site in runoff and once in water is persistent (hydrolysis half-life >234 days).
72-5 Invertebrate Life-Cycle, Estuarine/Marine	1	Fenamiphos	
72-4 Fish Early Life-Stage, Estuarine/Marine	1	Fenamiphos sulfoxide	Reserved pending results of acute tests with degradates.
72-4 Fish Early Life-Stage, Estuarine/Marine	1	Fenamiphos sulfone	
72-5 Invertebrate Life-Cycle, Estuarine/Marine	1	Fenamiphos sulfoxide	
72-5 Invertebrate Life-Cycle, Estuarine/Marine	1	Fenamiphos sulfone	
123-1 Aquatic Plants – Tier I	1 (2 species tested)	Fenamiphos sulfoxide	Required because of fenamiphos' terrestrial outdoor use pattern, its ability to move offsite in both surface and groundwater, and its labeled phytotoxicity warnings. Because of the phytotoxicity warnings fenamiphos testing should begin with Tier II testing but the degradates should begin with Tier I testing.
123-1 Aquatic Plants – Tier I	1 (2 species tested)	Fenamiphos sulfone	
123-2 Aquatic Plants – Tier I	1 (5 species tested)	Fenamiphos	

#### a. Terrestrial Hazard Assessment

In the Terrestrial Hazard Assessment all scientifically sound toxicity studies performed with avians, mammals, beneficial insects and plants using the technical grade of the active ingredient (TGAI), end-use formulations, degradates and metabolites are identified and avian and mammalian values are selected for calculating RQs. The specific avian and mammalian toxicity values selected for calculating terrestrial RQs are summarized in Table 12. The lowest available scientifically sound toxicity value for a given exposure regimen is typically selected unless stated otherwise. For this risk assessment it is assumed that avian toxicity values are indicators of toxicity for reptiles and amphibians.<sup>25, 26, and 27</sup>

<sup>25</sup> OPP Corn Cluster Document, A Special Review of 4 Corn Insecticides, Chapter 7, pages 148-149, April 1994. (Toxicity testing using bird test species as surrogates and indicators of the pesticide's toxicity to reptiles and terrestrial-phase amphibians and freshwater fish as surrogates and indicators of the pesticide's toxicity to aquatic-phase amphibians.)

<sup>26</sup> Tucker, R.K., and J.S. Leitzke, Comparative Toxicology of Insecticides for Vertebrate Wildlife and Fish, *Pharmacology Ther.*, Vol. 6, pp. 167-220, 1979.

<sup>27</sup> Suter, G.W., *Pesticide Effects on Terrestrial Wildlife*, L. Somerville and C.H. Walker, Eds., Taylor & Francis, New York, 1990.

**Table 12. Summary of Toxicity Values Used in Calculating Terrestrial Wildlife RQs**

Toxicity Study	Receptor Group <sup>a</sup> / Test Species	Measurement Endpoint			Relative Potency Category <sup>b</sup>	Form/ MRID No.
		Type	Value	Units		
Avian Acute Oral	Avian <sup>c</sup> / Bobwhite quail ( <i>Colinus virginianus</i> )	LD <sub>50</sub> <sup>d</sup>	1.6	mg a.i./kg-bw <sup>e</sup>	Very highly toxic	Technical/ 00121289
Avian Subacute Dietary	Avian <sup>c</sup> / Bobwhite quail ( <i>Colinus virginianus</i> )	LC <sub>50</sub> <sup>g</sup>	38	ppm of diet	Very highly toxic	Technical/ 0025959
Avian Reproduction	Avian <sup>c</sup> / Bobwhite quail ( <i>Colinus virginianus</i> )	NOEC <sup>h</sup>	2.0	ppm of diet	— <sup>i</sup>	Technical/ 121291
Mammalian Acute Oral	Mammals/ Laboratory rat ( <i>Rattus norvegicus</i> )	LD <sub>50</sub>	2.38, female 3.15, male	mg a.i./kg-bw	Very highly toxic	Technical/ 06F1693
Mammalian Acute Oral	Mammals/ Laboratory rat ( <i>Rattus norvegicus</i> )	LD <sub>50</sub>	2.6, male	mg a.i./kg-bw	Very highly toxic	Sulfone/ 00040215
Mammalian Development	Mammals/ Laboratory rat ( <i>Rattus norvegicus</i> )	NOAEL <sup>k</sup>	0.3	mg a.i./kg-bw	—	Technical/ 00071290
Honey Bee Contact	Beneficial Insects/ Domesticated Honey Bee ( <i>Apis mellifera</i> )	LD <sub>50</sub>	1.87	μg/bee <sup>l</sup>	Highly toxic	Technical/ 00036935

<sup>a</sup>Group of terrestrial organisms the receptor is representing.

<sup>b</sup>A substance is classified as practically nontoxic, slightly toxic, moderately toxic, highly toxic, and very highly toxic based on a comparison of the magnitude of its endpoint to predefined categories. Classification categories with associated magnitude ranges are provided for each endpoint in Table 13.

<sup>c</sup>Avian toxicity is used as an indicator of toxicity for reptiles and terrestrial-phase amphibians.

<sup>d</sup>Median lethal dose = dose at which 50% of the exposed population is expected to die.

<sup>e</sup>mg a.i./kg-bw = milligrams of active ingredient per kilogram of body weight

<sup>f</sup>Technical grade of fenamiphos

<sup>g</sup>Median lethal concentration = concentration at which 50% of the exposed population is expected to die.

<sup>h</sup>No observable effect concentration = the highest test concentration in which the effect was not found to be statistically different from the control.

<sup>i</sup>No classification scheme currently exists for this endpoint.

<sup>j</sup>Fenamiphos sulfone

<sup>k</sup>No observable adverse effect level = the highest test dose in which the effect was not found to be statistically different from the control.

<sup>l</sup>microgram per bee

To aid in characterizing a chemical's poisoning potential relative to other substances its toxicity results are classified or rated, based on the magnitude of the chemical required to illicit a response, as practically nontoxic, slightly nontoxic, moderately toxic, highly toxic, or very highly toxic. The toxicity rating or classification schemes for avian and mammalian tests used in this assessment are provided in Table 13.

**Table 13. Toxicity Classification Chart for Terrestrial Receptor Toxicity Values**

Toxicity Study (Endpoint)	Classification Scheme					Units
	very highly toxic	highly toxic	moderately toxic	slightly toxic	practically nontoxic	
Avian and mammalian acute oral (LD <sub>50</sub> )	<10	10 to 50	51 to 500	501 to 2,000	>2,000	mg a.i./kg-bw
Avian and mammalian subacute dietary (LC <sub>50</sub> )	<50	50 to 500	501 to 1,000	1,001 to 5,000	>5,000	mg a.i./kg of diet (or ppm a.i. in diet)
Avian reproduction and mammalian development and reproduction (NOAEL)	— No classification scheme is currently available for the avian reproduction test. —					
Mammalian acute dermal (LD <sub>50</sub> )	≤200	>200 to 2,000	>2,000 to 20,000		>20,000	mg a.i./kg-bw
Mammalian acute inhalation (LC <sub>50</sub> )	≤0.20	>0.20 to 2.0	>2.0 to 20		>20	mg a.i./liter of air
Honey bee acute contact (LD <sub>50</sub> )	<2		2 to 10.99		>11	μg/bee

**(1) Birds, Acute and Subacute Toxicity Tests****(a) Acute Oral Toxicity**

The avian acute oral test is a single-dose, orally administered, in-laboratory study designed to estimate the quantity of a substance in milligrams of a.i. per kilogram of body weight (mg a.i./kg-bw) required to kill fifty percent of an exposed test population (median lethal dose; LD<sub>50</sub>). The substance is administered by oral intubation to adult birds which are then observed for 14 days after dosing.

An acute oral toxicity study using the TGAI is required to establish the toxicity of fenamiphos to birds (Guideline 71-1[A]). The preferred test species is either the Mallard Duck (a wild waterfowl) or the Bobwhite Quail (an upland game bird). Seven avian acute oral toxicity tests conducted with the TGAI and two studies conducted with the end-use formulation Nemacur 3 have been reviewed and analyzed by EFED and classified as either core or supplemental; results of these studies are provided in Table F1.

The acute oral LD<sub>50</sub>s for both the TGAI and the end-use formulation Nemacur 3 were between 0.5 and 15 mg a.i./kg-bw/day, which classifies fenamiphos and its end-use product as very highly toxic to birds (Table 13). One study was classified as core (MRID 00121289), it was conducted with Bobwhite Quail and fulfills the guideline (71-1[A]) requirement. The Bobwhite Quail LD<sub>50</sub> of 1.6 mg a.i./kg-bw, from the core classified study, was selected for calculating RQs for terrestrial wildlife exposure scenarios in Section 5, Risk Assessment (Table 12). Although there were LD<sub>50</sub>s lower than 1.6 mg a.i./kg-bw reported, they were not selected for use in the risk characterization because although they were scientifically sound too few birds were tested at each dose level, the test material was impure, test duration was too short or the surrogate test subjects were too young or unacceptable whereas the core study was scientifically sound and met protocol requirements.

**(b) Avian Subacute Dietary Test**

The avian dietary subacute test is a 5-day dietary exposure, in-laboratory study designed to estimate the quantity of a substance in the diet required to kill fifty percent of an exposed test population (median lethal concentration; LC<sub>50</sub>). The quantity of substance in the diet is expressed in terms of milligrams of a.i. per

kilogram of diet (mg a.i./kg) or ppm of a.i. in the diet. The test substance is mixed with the food and the treated food is fed *ad libitum* for 5 days to juvenile birds followed by three days of untreated, “clean”, diet.

Two subacute dietary toxicity studies conducted with the TGAI, one conducted with a wild waterfowl and the other with an upland game species are required (Guideline 71-2[A]) to establish the toxicity of fenamiphos to birds. The preferred test species are 5-day old Mallard Ducks (a wild waterfowl) and 10- to 14-day old Bobwhite Quail (an upland game bird). Three avian subacute dietary studies conducted with the TGAI have been reviewed, analyzed, and classified as scientifically sound studies by EFED; results of these studies are summarized in Table F2. Two of the studies were classified as core (MRIDs 00025959 and 00025958), one with Bobwhite Quail and one with the Mallard Duck, which fulfills the guideline (71-2[A]) requirements. The  $LC_{50}$ s ranged from 38 ppm (Bobwhite Quail) to 316 ppm (Mallard Duck) which classifies fenamiphos as a highly toxic to very highly toxic substance in the diet (Table 13). The lowest  $LC_{50}$ , 38 ppm, was selected for calculating acute avian dietary RQs (Table 12).

### (c) Avian Acute and Subacute Data Needs

Avian testing with degradates may be required by EFED if the parent material is short-lived and if a large percentage of any degradate is formed which is the case for fenamiphos. Fenamiphos sulfoxide and fenamiphos sulfone are the primary degradates in soil and water. Additionally fenamiphos sulfone has been tested with mammals and identified to be as toxic as the parent compound (i.e.,  $LC_{50}$  for male laboratory rats is 2.6 ppm for fenamiphos sulfone and ranges from 2.4 to 3.5 ppm for fenamiphos) which indicates that the same may be true for birds. Therefore two avian acute and subacute tests, one each using fenamiphos sulfoxide and fenamiphos sulfone are needed (Table 11). An acute avian oral toxicity study using Nemacur technical and the fenamiphos sulfone and sulfoxide metabolites was submitted in 1986 but was classified invalid (MRID 0025963).

## (2) Birds, Chronic Toxicity Tests

### (a) Avian Reproduction Test

Avian reproduction studies using the Bobwhite Quail and Mallard Duck are dietary, in-laboratory tests designed to estimate the highest quantity of a substance in the diet that will not adversely affect the reproductive capabilities of a test population of birds. The test substance is administered by mixing it into the diet throughout the adult birds breeding cycle. At the start of the test, the birds are approaching their first breeding season and are generally 18-to-23 weeks old. The onset of the exposure period is at least 10 weeks prior to egg laying. Exposure duration during egg laying is generally 10 weeks but if reduced egg laying is noted an additional three week withdrawal period is added to the test. A number of reproductive measurement endpoints are observed (e.g., eggshell thinning; eggshell cracking; number of eggs laid, fertilized eggs, viable embryos, hatchlings and 14-day old survivors; and hatchling and 14-day old weights). The result of the test is expressed as the no observable adverse effect level (NOAEL) which is the highest concentration in the diet (ppm of the substance) that produced no statistical difference in any of the measurement endpoints from that of the control and the lowest observable adverse effect level (LOAEL) which is the lowest concentration in the diet (ppm) that produced a statistically detectable effect in one or more measurement endpoints.

The avian reproduction test with the Bobwhite Quail and Mallard Duck using the TGAI was required for fenamiphos (Guideline 71-4[A]) because the following conditions were met: (1) birds may be subject to repeated exposure to the pesticide, especially preceding or during the breeding season, and (2) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be



(Health Effects Divisions's [HED's] 1994 Fenamiphos RED Chapter). A Bobwhite Quail and Mallard Duck study were reviewed by EFED and classified as core studies fulfilling the guideline 71-4(A) requirements; results of these tests are tabulated in Table F3.

Statistically significant reduction in the number of eggs laid/set, viable embryos, hatchlings, and survivors occurred when Mallard Duck mated pairs were fed diets containing 16.0 ppm or greater of fenamiphos. The most sensitive endpoint was the number of 14-day hatchlings. Similarly, a statistically significant decrease in normal hatchlings and survivors was observed when Bobwhite Quail mated pairs were fed diets containing 8 ppm or more of fenamiphos. The lowest NOAEL of 2 ppm was selected for calculating avian chronic risks (Table 12).

### **(b) Avian Chronic Testing Data Needs**

Chronic avian toxicity testing (Guideline 71-4[A]) of fenamiphos sulfoxide and fenamiphos sulfone is reserved pending review of results of the avian acute oral and subacute dietary tests with these degradates.

### **(3) Mammals, Acute and Chronic Toxicity Tests**

In lieu of wild mammal testing, results of mammalian tests submitted to the Agency to extrapolate fenamiphos' toxicity to humans are also used to estimate effects to wild mammals. Wild mammal testing is required on a case-by-case basis, depending on the results of the lower tier studies (acute and subacute testing), intended use pattern, and pertinent environmental fate characteristics.

#### **(a) Mammalian Acute Oral Toxicity Tests**

**TGAI and End-Use Formulations.** Results of scientifically sound mammalian acute oral toxicity tests conducted with the TGAI and with the end-use formulations, Nemacur 3, 10G, and 15G, are provided in Tables F4 and F5, respectively; eleven tests are reported for fenamiphos technical and five tests are reported for end-use formulations. The animals tested are used in this risk assessment as surrogate test species for wild mammals. The animals tested represent the orders Rodentia (small to medium-sized gnawing mammals), and Lagomorpha and Carnivora, (plant-eating and flesh-eating mammals, respectively). For fenamiphos technical, the mammalian LD<sub>50</sub> values range from 2.38 mg a.i./kg-bw (female laboratory rat from a core study, MRID 06F1693) to greater than 75 mg a.i./kg-bw (guinea pig from supplemental study MRID 00154492). Based on these results fenamiphos is classified as a moderately toxic to very highly toxic substance (Table 13) when ingested. Likewise, the LD<sub>50</sub> values based on exposures with the end-use formulations ranged from 10 mg a.i./kg-bw (fasted male laboratory rats exposed to Nemacur 15G, MRID 099496) to 100 mg a.i./kg-bw (laboratory rats exposed to Nemacur 10G; MRIDs 00154492 and 001310). The lowest value, 2.38 mg a.i./kg-bw for the rat from a core study, was selected for use in calculating mammalian acute oral RQs in the risk assessment.

**Degradates and/or Metabolites.** Mammalian acute oral tests were conducted using the fenamiphos metabolites, MTMC sulfoxide, MTMC sulfone and 4-methyl-mercapto-m-cresol and laboratory rats (Table F5); LD<sub>50</sub> values ranged from 1,175 to 1,854 mg a.i./kg-bw indicating that on an acute oral basis these metabolites are considered only slightly toxic substances to mammals. However, the metabolite and environmental degradate fenamiphos sulfone, had an LD<sub>50</sub> value of 2.6 mg a.i./kg-bw which is as toxic as the parent compound and is classified as a very highly toxic substance (Table 13). Additionally, the metabolite desisopropyl fenamiphos sulfoxide is as toxic as the parent compound. Test species were observed experiencing increased salivation, urination, diarrhea, tremors and convulsions prior to death

(MRID 00099496, 00052532, 00040215, and 00039700). The fenamiphos sulfone LD<sub>50</sub> of 2.6 ppm was selected to calculate risks from ingestion of fenamiphos sulfone residues (Table 12).

### (b) Mammalian Acute Dermal and Inhalation Toxicity Testing

In addition to acute oral routes of exposure, terrestrial vertebrates entering the field after treatment may be acutely exposed to fenamiphos and its degradates dermally and/or through inhalation. Dermal and inhalation values are not used to calculate terrestrial wildlife RQs in the standard screening risk assessment, however, the data is provided to fully characterize the toxicity of fenamiphos for all potential routes of exposure and to semi-qualitatively evaluate the importance of these pathways.

**Dermal.** Mammalian dermal LD<sub>50</sub> values for fenamiphos and its end-use formulations are listed in Table F6 (MRID 00037962, 0000154492, 00001310, 001G1168, and 42476001). Values for fenamiphos technical ranged from 72.9 to 225 mg a.i./kg-bw which classifies fenamiphos as a highly toxic to very highly toxic substance dermally. Also, the emulsifiable formulation, Nemacur 3, was found to be very highly toxic dermally. However, the granular formulations were rated as slightly toxic to highly toxic dermally.

**Inhalation.** The acute inhalation toxicity results for technical fenamiphos and end-use formulations, Nemacur 3 and 15G, are provided in Table F7. All of these studies were deemed scientifically sound; however, certain studies did not meet minimum guideline requirements and were classified supplemental. Based on the results fenamiphos is very highly toxic to mammals who receive low air concentrations for short durations (LC<sub>50</sub> about 0.2 milligrams a.i. per liter of air per hour [mg/L/1 hr]) or very low air concentrations for prolonged durations (0.02 mg/L/4 hr). The granular end-use formulation, Nemacur 15G, was not as toxic via inhalation as the emulsifiable or technical forms of fenamiphos; when fumes were inhaled directly from granular applications the LC<sub>50</sub> was >20 mg/L/1hr (MRID 00001311) which is classified as only slightly toxic via inhalation.

### (c) Mammalian Subchronic Toxicity Testing

Two mammalian subchronic feeding studies (Table F8) were submitted. Fenamiphos residues in the diet at levels greater than 10 ppm caused increased mortality and lung and thyroid gland weights in mammals. Depressed cholinesterase blood levels occur at occurred at fenamiphos concentrations greater than 1 ppm in the diet. (MRID 0012414).

### (d) Mammalian Developmental and Reproductive Toxicity Testing.

Three mammalian developmental studies and two mammalian reproductive studies were reviewed and found scientifically sound (MRID 403476020, 00071290, 41225401, 00112414, and 41908901) and were rated as core studies; results are provided in Table F9.

**Developmental Studies.** Treatment-related effects observed in developmental tests with rabbits included fused sternebrae and increased mortality in the offspring when the mother rabbit was exposed to daily doses of 1.0 mg/kg-bw/day (33 ppm diet<sup>28</sup>) for 10 days during gestation. In the rat developmental study, observations on the pups were not recorded; however, the maternal NOAEL is 3.0 mg/kg-bw/day (60 ppm diet<sup>11</sup>) due to weight loss, cholinesterase depression, loss of balance, and increased mortality.

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Conversion to ppm of diet based on a dose of 1 mg/kg-bw/day = 20 ppm for adult rats and 33 ppm for rabbits (Nelson, 1975).

**Reproductive Studies.** The mammalian 2-generation reproduction study, using laboratory rats as the test subjects, indicates dose-related decreases in pup body weight. Cholinesterase levels were depressed in both the parents and offspring at the parent's dietary intake levels exceeding 2.5 ppm.

The lowest NOAEL of 2.5 ppm a.i. in the diet from the 2-generation adult rat reproductive study is selected for calculating chronic mammalian RQs (Table 12).

### **(3) Beneficial Insects**

#### **(a) Acute Insect Contact Test**

The purpose of this study is to develop data on the acute contact toxicity of a substance to insects using the domestic honey bee, *Apis mellifera*. The acute contact insect test is a single-dose, in-laboratory study designed to estimate the quantity of a substance (micrograms of a.i. per bee [ $\mu\text{g a.i./bee}$ ]) required to cause fifty percent mortality (median lethal dose;  $\text{LD}_{50}$ ) upon contact in a test population of bees. The test substance is administered to worker bees by one of two methods: whole body exposure to the test substance in a nontoxic dust diluent or, topical exposure via microapplicator.

A honey bee acute contact  $\text{LD}_{50}$  study using the TGAI is required if the proposed use will result in exposure to honey bees. A single honey bee acute contact  $\text{LD}_{50}$  study (MRID 00036935) was reviewed and classified as core (Table F10) fulfilling the guideline requirements (141-1). EFED uses this data to assess acute hazards to bees and other beneficial insects. The reported  $\text{LD}_{50}$  was  $1.87 \mu\text{g/bee}$  which is rated as a highly toxic substance to bees (Table 13).

#### **(b) Nontarget Insect Data Needs**

As indicated in the 1987 Fenamiphos Registration Standard, a honey bee foliage residue study is required for the typical end-use product if exposures are anticipated. A honey bee residue study (141-2) is required for the emulsifiable concentrate formulation, Nemacur 3, for its fruit and vegetable crop uses as banded and broadcast applications to these crops are anticipated to result in contact exposure to honey bees. Nemacur 3 has the following risk reduction statements on its label: "Do not use mini- sprinklers. Use only coarse sprays directed at soil to eliminate spray drift. Aerial application of this product is prohibited." Although it is anticipated that these statements will reduce spray drift, they will not eliminate it; honey bees and other beneficial insects still may be exposed to Nemacur 3 residues on blooming weeds growing in and around the treatment area.

A systemic pesticide, fenamiphos, will be translocated post-application throughout the plant crop and weeds growing in or around the treatment area. Residue data (HED's 1994 Fenamiphos RED Chapter) provided to the Agency to assess tolerances provides some insight into the time intervals required for residues to decline post-application to be within maximum allowable limits. Therefore, honey bees and other nontargets may have greater potential for extended exposures to fenamiphos through exposure to fenamiphos-laden nectar, pollen and other plant parts of blooming plants growing in and around the treated area. To determine the residues in nectar, pollen and other plant parts used as food items by nontarget insects, EFED requests that the registrant collect and submit nectar, pollen and plant residue data on the following insect/bird/bat-pollinated food crops at full bloom in fenamiphos treated areas: cherry, peach, orange, strawberry, cotton, banana and peanut.

#### (4) Terrestrial Plants

Terrestrial plant seedling emergence and vegetative vigor tests are required for herbicides and other pesticides, on a case-by-case basis. Terrestrial plant testing is required for fenamiphos because of its terrestrial outdoor use pattern; its ability to move offsite in both surface and groundwater; and its phytotoxicity warnings on its Namacur labels. In addition, endangered or threatened plant species are associated with many fenamiphos use sites, and therefore, may be affected.

Plant protection data requirements follow an ordered testing scheme, consisting of Tiers I, II and III. Tier I tests measure the response of plants, relative to a control, at a test level that is equal to the highest use rate (expressed as lbs a.i./A). Tier II phytotoxicity testing measures the response of plants, relative to a control, at five or more test concentrations. For Tier I and II seedling emergence and vegetative vigor trials, the following plant species and groups should be tested: (1) six species of at least four dicotyledonous families, one species of which is soybean (*Glycine max*), and the second of which is a root crop, and (2) four species of at least two monocotyledonous families, one of which is corn (*Zea mays*). Tier III, a terrestrial field study, evaluates the Typical End-Use Product (TEP) in the environment and is triggered when a detrimental effect occurs at 25% or greater to one or more of the plant test species in the lower tiers.

Because fenamiphos bears phytotoxic warnings on the Namacur labels, testing should begin at Tier II. The registrant should submit for EPA review a Tier II seedling emergence and vegetative vigor study (123-1) using the technical, fenamiphos, as the test substance. The degradates, fenamiphos sulfone and sulfoxide, should also be tested beginning at Tier I.

#### b. Aquatic Hazard Assessment

Provided in this Section are descriptions of the types of toxicity tests required to assess the risks of fenamiphos and its degradates to freshwater and saltwater (estuarine/marine) organisms, lists of the aquatic toxicity tests which have been performed and found scientifically sound, and the identity of toxicity results which are used in calculating RQs in the risk assessment. The toxicity tests and values selected for calculating aquatic organism RQs are summarized in Table 14. Where multiple toxicity values for a given test type were available, the lowest value was selected for use in calculating RQs unless otherwise noted.

**Table 14. Summary of Toxicity Values Used in Calculating Aquatic Organism RQs**

Toxicity Study	Receptor Group <sup>a</sup> / Test Species	Measurement Endpoint			Relative Toxicity Category <sup>b</sup>	Form/ MRID No.
		Form	Value	Units		
Freshwater Fish Acute	Freshwater Fish and Amphibians/ Bluegill Sunfish ( <i>Lepomis macrochirus</i> )	LC <sub>50</sub> <sup>c</sup>	9.5	μg/l <sup>d</sup>	Very highly toxic	Technical/ 00025962
Freshwater Fish Early Life-Stage	Freshwater Fish and Amphibians/ Rainbow trout ( <i>Salmo gairdneri</i> )	NOEC <sup>e</sup>	3.8	μg/l	– <sup>f</sup>	Technical/ 41064301
Freshwater Invertebrate Acute	Freshwater Invertebrates/ Daphnia ( <i>Daphnia magna</i> )	LC <sub>50</sub>	1.9	μg/l	Very highly toxic	Technical/ 40799706
Freshwater Invertebrate Life- Cycle	Freshwater Invertebrates/ Daphnia ( <i>Daphnia magna</i> )	NOEC	0.12	μg/l	–	Technical/ 43121401, 40922201
Estuarine/Marine Acute	Estuarine/Marine Aquatic Organisms/ Mysid Shrimp ( <i>Mysidopsis bahia</i> )	LC <sub>50</sub>	6.2	μg/l	Very highly toxic	Technical/ 40799708

<sup>a</sup>Group of aquatic organisms the receptor is representing.

<sup>b</sup>A substance is classified as practically nontoxic, slightly toxic, moderately toxic, highly toxic, and very highly toxic based on a comparison of the magnitude of its endpoint to predefined categories. Classification categories with associated ranges are provided for each endpoint in Table 15.

<sup>c</sup>Median lethal concentration = concentration at which 50% of the exposed population is expected to die.

<sup>d</sup>micrograms of active ingredient per liter

<sup>e</sup>No observable effect concentration = the highest test concentration in which the effect was not found to be statistically different from the control.

<sup>f</sup>Relative toxicity categories have not been established for this endpoint.

A toxicity classification scheme is provided in Table 15 for the aquatic toxicity tests. This rating scheme provides a way to compare the poisoning potential of chemicals. Actual risk from poisoning by a substance is evaluated in Section 5, Risk Assessment, which integrates estimated environmental concentrations, pathways, receptors, and toxicity values.

**Table 15. Toxicity Classification Chart for Aquatic Toxicity Test Results**

Toxicity Study (Endpoint)	Classification Scheme					Units
	very highly nontoxic	highly toxic	moderately toxic	slightly toxic	practically nontoxic	
Acute and Early Life-Stage, Fish and Invertebrates Toxicity Tests (LC <sub>50</sub> )	<0.1 (<100)	0.1 to 1.0 (100 to 1,000)	>1.0 to 10 (>1,000 to 10,000)	>10 to 100 (>10,000 to 100,000)	>100 (>100,000)	ppm (ppb)
Life-Cycle Tests, Fish and Invertebrates (NOEC)	— No classification scheme is currently available for the life-cycle tests. —					

### (1) Freshwater Fish, Acute

The freshwater fish acute test is a 96-hour exposure, in-laboratory test with juvenile fish, designed to estimate the quantity of a substance in water (ppm) required to kill fifty percent of an exposed test population (median lethal concentration; LC<sub>50</sub>). Two acute freshwater fish toxicity studies one with a cold water species and one with a warm water species using the TGAI are required (Guideline 72-1) to establish the toxicity of fenamiphos to freshwater fish. The preferred test species are rainbow trout (coldwater fish), and bluegill sunfish (warmwater fish). Testing using the degradates, fenamiphos sulfoxide and fenamiphos sulfone, is also required since the parent material, fenamiphos, is short-lived and these degradates form in large percentage.

Ten acute freshwater fish studies were reviewed and classified as scientifically sound (Table F11); three were conducted using fenamiphos technical, two using fenamiphos sulfoxide, one with fenamiphos sulfone, two each with the end-use products Nemacur 3 and 10G (MRIDs 00025962, 00114012, 40799704, 40799701 and 00114015). Due to the low quantities of fenamiphos and its degradates required to elicit a response by aquatic animals, the LC<sub>50</sub> values are expressed in ppb rather ppm; one ppm equals 1,000 ppb. The TGAI and end-use product studies were all classified as core studies fulfilling the Guideline 72-1 requirements. For fenamiphos technical and the end-use formulations the LC<sub>50</sub>s ranged from 4.5 to 563 ppb of a.i., indicating that fenamiphos is a highly toxic to very highly toxic substance to freshwater fish. The lowest LC<sub>50</sub> from the TGAI core rated studies of 9.5 ppb a.i. was selected for calculating acute RQs for fish (Table 14).



The degradates, fenamiphos sulfone and sulfoxide, are rated as moderately toxic substances to freshwater fish on an acute basis; the  $LC_{50}$  is 1,173 ppb a.i. for fenamiphos sulfone and ranges from 2,000 to 2,653 ppb a.i. for fenamiphos sulfoxide. For freshwater fish, the degradates do not appear to be as toxic as the parent compound.

## **(2) Freshwater Fish, Chronic**

### **(a) Early Life-Stage Test**

The fish early life-stage test is an in-laboratory test designed to estimate the highest quantity of a substance in water (ppm) required which will not adversely effect the reproductive capabilities of a test population of fish (no observable effect concentration; NOEC) and the lowest quantity of a substance in water which will adversely effect the reproductive capabilities of the test population (lowest observable effect concentration; LOEC). Two to twenty-four hour old fish eggs, fertilized prior to exposure to the test substance or fertilized in the test solution, are monitored until hatching is about 90% complete or until 48 hours after first hatch. The time to first hatch varies depending on the species tested; the preferred test species is rainbow trout. The test should be performed using flow-through conditions.

A freshwater fish early life-stage test using the TGAI is required because the end-use product is expected to be transported to water from ground applications such that its presence in water is likely to be recurrent; in addition, the pesticide is persistent in water with a hydrolysis half-life greater than 234 days. A single early-life stage test using Rainbow Trout was conducted with fenamiphos technical and was classified as a core study (Table F12) fulfilling guideline requirements (MRID 41064301). The NOEC and LOEC for the TGAI study were determined to be 0.0038 and 0.0074 ppm a.i. (3.8 and 7.4 ppb a.i.), respectively, based on the measurement endpoints of larval length and weight. However, delays in growth and development of fry were demonstrated to occur at concentrations of fenamiphos in water as low as 0.0039 ppm (3.9 ppb). The NOEC of 3.8 ppb a.i. was selected as the fish early life-stage toxicity value for calculation of RQs (Table 14).

### **(b) Freshwater Fish Chronic Toxicity Test Data Needs**

Early-life stage testing of the two degradates, fenamiphos sulfoxide and fenamiphos sulfone, is required because the end-use product is expected to be transported to water from the intended use site, and fenamiphos is persistent in water.

A freshwater fish life-cycle test (Guideline 72-5) using the TGAI is required because the results in freshwater fish early life-stage toxicity test using the TGAI indicate that fish reproductive physiology may be affected by fenamiphos exposure, and the EEC is greater than one-tenth (0.1) the NOEC value of 3.8 ppb in the freshwater fish early life-stage toxicity test (i.e., 60-day EEC values range from 3.6 to 329 ppb a.i., which are from 0.95 to 86.5 times the NOEC).

### **(3) Freshwater Invertebrates, Acute**

#### **(a) Acute Invertebrate Toxicity Tests**

The freshwater invertebrate acute test is a 48-hour exposure, in-laboratory test designed to estimate the quantity of a substance in water (ppm) required to immobilize (or kill) fifty percent of an exposed test population (median effect concentration; EC<sub>50</sub>). Because it is not always possible in these tests to verify that an immobilized invertebrate is dead without too much handling, immobilization is used as a surrogate for death. A freshwater aquatic invertebrate toxicity test using the TGAI is required to assess the toxicity of fenamiphos to freshwater invertebrates. The preferred test organism is *Daphnia magna*, but early instar amphipods, stoneflies, mayflies, or midges may also be used.

Acute freshwater invertebrate results for a study using TGAI, a study with fenamiphos sulfoxide, and one with the end-use formulation, NemaCur 3 are summarized in Table F13 (MRIDs 40799706, 43183501, and 41497701). The acute EC<sub>50</sub> is 1.9 ppb a.i. for the TGAI and 7.5 ppb a.i. for the degradate, fenamiphos sulfoxide, which ranks these as very highly toxic substances to aquatic organisms (Table 13). Unlike fish, the degradate, fenamiphos sulfoxide, appears to be only slightly less toxic than the parent compound to freshwater invertebrates.

#### **(b) Data Needs**

The test using fenamiphos sulfoxide was classified supplemental because the raw data was not submitted, and the reported dissolved oxygen levels and pH measurements were inaccurately measured. If the raw data were submitted, then the study potentially could be upgraded; otherwise, the study should be repeated. In addition, acute freshwater invertebrate testing is required on fenamiphos sulfone because it has been identified as a degradate of toxicological concern.

### **(4) Freshwater Invertebrates, Chronic**

#### **(a) Life-Cycle Toxicity Test**

A freshwater aquatic invertebrate life-cycle test is a *D. magna*, 21-day exposure, in-laboratory test. The test is designed to estimate the highest quantity of a substance in water (ppm) that does not effect the reproductive capability of freshwater invertebrates (NOEC) and the lowest quantity that does effect the reproductive capability (LOEC). One freshwater invertebrate *D. magna* study using the fenamiphos TGAI was submitted and is scientifically sound and fulfills the guideline (72-4) requirements. The results of the study are summarized in Table F14. Based on the most sensitive endpoints, number of neonates produced per reproductive day and mean body length, the NOEC is 0.12 ppb (MRID 43121401).

#### **(b) Data Needs**

A *D. magna* life-cycle test using the degradate fenamiphos sulfoxide should be submitted. Chronic testing is reserved for fenamiphos sulfone pending results of the acute freshwater invertebrate test.

## (5) Estuarine/Marine Animals, Acute

### (a) Acute Toxicity Tests

Acute toxicity testing with estuarine and marine organisms (fish, shrimp and oyster embryo-larvae or shell deposition) using fenamiphos is required because it is expected to reach the estuarine/marine environment in significant concentrations because it is very mobile in soil and very soluble in water. The preferred test organisms are the Sheepshead Minnow, Mysid Shrimp and Eastern Oyster. One study for each of these species was performed and the studies were reviewed and classified as core studies fulfilling Guideline 72-3 requirements. Results of these tests are tabulated in Table F15 (MRIDs 40799709, 40799710 and 40799708). The acute  $EC_{50}$  and  $LC_{50}$  results ranged from 6.2 ppb a.i. for the Mysid Shrimp to 1,650 ppb for the Eastern Oyster study which ranks fenamiphos as a moderately toxic to very highly toxic substance to saltwater organisms (Table 15). The lowest  $EC_{50}/LC_{50}$  value of 6.2 ppb a.i. was selected for use in calculating acute RQs for estuarine/marine organisms (Table 14).

### (b) Data Needs

Acute estuarine/marine testing is required for fenamiphos sulfoxide and sulfone because they have been identified as degradates of toxicological concern. These degradates have also been identified as equally mobile as the parent, and therefore, subject to moving offsite in ground and surface waters.

## (6) Estuarine/Marine Animals, Chronic

An estuarine/marine invertebrate life-cycle toxicity test and a fish early-life stage test using fenamiphos is required because the end-use products are expected to be transported to estuarine/marine environments from the intended use site. Chronic testing on fenamiphos sulfone and sulfoxide is reserved pending results of acute estuarine/marine testing. The guideline (72-4) is not fulfilled.

## (7) Aquatic Plants

Aquatic plant testing is required for fenamiphos because of its terrestrial outdoor use pattern; its ability to move offsite in both surface and groundwater; and its phytotoxicity warnings on its Nemacur labels. In addition, endangered or threatened plant species are associated with many fenamiphos use sites, and therefore, may be affected. Like terrestrial plant testing, aquatic plant testing follows a tiered testing scheme, Tier I, II and III. The following are the recommended species that should be tested at Tier I: *Kirchneria subcapitata* and *Lemna gibba*. The following are the recommended test species that should be tested at Tier II: *Kirchneria subcapitata*, *Lemna gibba*, *Skeletonema costatum*, *Anabaena flos-aquae*, and a freshwater diatom. Testing with the fenamiphos technical should begin at Tier II. The degradates, fenamiphos sulfone and sulfoxide, should also be tested beginning at Tier I. This guideline requirement (123-2) is not fulfilled.

## 5. Ecological Risk Assessment

To characterize the environmental risk from the use of fenamiphos requires an integration of the potency (or toxicity) of fenamiphos or its degradates with that of estimated exposure concentrations from its use and application rates. EFED's standard screening level risk assessment approach integrates the toxicity and exposure data using the RQ method. The RQs are then compared to the OPP's presumptive levels of concern. RQ calculation procedures and LOCs are provided in the following sections. Additionally, results of the RQ calculations for fenamiphos uses are provided and are compared to LOCs.

### a. RQ Calculation Methods

Maximum and mean acute and chronic RQs for terrestrial and aquatic receptors are calculated by dividing maximum and mean EECs for a given media by acute and chronic measures of toxicity for a given receptor exposed to that media and pathway. The calculations used in this risk assessment for avian and mammalian indicator species and acute and chronic RQs are provided below.

#### Birds (reptiles and terrestrial-phase amphibians) and Mammals

$$\text{Maximum Acute RQ}_{\text{plant \& insect residue}} = \frac{\text{Maximum EEC} \left( \frac{\text{mg of a.i.}}{\text{kg food item}} \right)}{\text{LC}_{50} \left( \frac{\text{mg of a.i.}}{\text{kg diet}} \right)} \quad \text{Equation 5}$$

$$\text{Mean Acute RQ}_{\text{plant \& insect residue}} = \frac{\text{Mean EEC} \left( \frac{\text{mg of a.i.}}{\text{kg food item}} \right)}{\text{LC}_{50} \left( \frac{\text{mg of a.i.}}{\text{kg of diet}} \right)} \quad \text{Equation 6}$$

$$\frac{\text{Acute RQ}_{\text{granular}}}{\text{ft}^2} = \frac{\text{Maximum EEC}_{\text{granular}} \left( \frac{\text{mg a.i.}}{\text{ft}^2} \right)}{\text{LD}_{50} \left( \frac{\text{mg a.i.}}{\text{kg - bw}} \right) \times \text{Body Weight (grams)} \times \frac{1 \text{ (kg)}}{1000 \text{ (grams)}}} \quad \text{Equation 7}$$

$$\text{Maximum Chronic RQ}_{\text{plant \& insect residue}} = \frac{\text{Maximum EEC} \left( \frac{\text{mg a.i.}}{\text{kg of food item}} \right)}{\text{NOEL} \left( \frac{\text{mg a.i.}}{\text{kg of diet}} \right)} \quad \text{Equation 8}$$

$$\text{Mean Chronic RQ}_{\text{plant \& insect residue}} = \frac{\text{Mean EEC} \left( \frac{\text{mg a.i.}}{\text{kg of food item}} \right)}{\text{NOEL} \left( \frac{\text{mg a.i.}}{\text{kg of diet}} \right)} \quad \text{Equation 9}$$

## Aquatic Organisms (aquatic-phase amphibians)

$$\text{Acute RQ}_{\text{surface water}} = \frac{\text{Acute EEC} \left( \frac{\mu\text{g a.i.}}{\text{liter}} \right)}{\text{LC}_{50} \left( \frac{\mu\text{g a.i.}}{\text{liter}} \right)} = \frac{\text{Acute EEC (ppb a.i.)}}{\text{LC}_{50} \text{ (ppb a.i.)}} \quad \text{Equation 10}$$

$$\text{Acute RQ}_{\text{surface water}} = \frac{\text{Acute EEC} \left( \frac{\mu\text{g a.i.}}{\text{liter}} \right)}{\text{EC}_{50} \left( \frac{\mu\text{g a.i.}}{\text{liter}} \right)} = \frac{\text{Acute EEC (ppb a.i.)}}{\text{EC}_{50} \text{ (ppb a.i.)}} \quad \text{Equation 11}$$

$$\text{Chronic RQ}_{\text{surface water}} = \frac{21\text{-day EEC} \left( \frac{\mu\text{g a.i.}}{\text{liter}} \right)}{\text{NOEC} \left( \frac{\mu\text{g a.i.}}{\text{liter}} \right)} = \frac{21\text{-day EEC (ppb a.i.)}}{\text{NOEC (ppb a.i.)}} \quad \text{Equation 12}$$

### b. LOCs

The LOCs are criteria used by OPP to identify which RQs indicate a potential risk to nontarget organisms exists and the need to consider regulatory action. More specifically, the criteria identifies those pesticides for a given use that have the potential to cause adverse effects on nontarget organisms even when applied according to labeled rates and methods. The RQ values associated with a given LOC and a presumption of risk category are summarized in Table 16. Risk presumption categories are:

- **acute risk** - significant potential for acute risk; regulatory action may be warranted in addition to restricted use classification;
- **acute restricted use** - potential for acute risk may be mitigated through restricted use classification;
- **acute endangered species** - level of concern for endangered species exceeded; regulatory action may be warranted;
- **chronic risk** - the potential for chronic risk is considerable; regulatory action may be warranted.

**Table 16. LOC Classification Scheme.**

Risk Presumption	RQ LOC	Type of RQ
<b>Birds (reptiles and terrestrial-phase amphibians) and Wild Mammals</b>		
Acute risk	≥0.5	Maximum or Mean Acute RQ <sub>plant &amp; insect residue</sub> or Acute RQ <sub>granular</sub> /ft <sup>2</sup>
Acute restricted use	≥0.2	Maximum or Mean Acute RQ <sub>plant &amp; insect residue</sub> or Acute RQ <sub>granular</sub> /ft <sup>2</sup> or LD <sub>50</sub> < 50 mg a.i./kg-bw
Acute endangered species	≥0.1	Maximum or Mean Acute RQ <sub>plant &amp; insect residue</sub> or Acute RQ <sub>granular</sub> /ft <sup>2</sup>
Chronic risk	>1	Maximum or Mean Chronic RQ <sub>plant &amp; insect residue</sub>



**Table 16. LOC Classification Scheme.**

Risk Presumption	RQ LOC	Type of RQ
<b>Aquatic Animals (including aquatic-phase amphibians)</b>		
Acute risk	$\geq 0.5$	Acute RQ <sub>surface water</sub>
Acute restricted use	$\geq 0.1$	Acute RQ <sub>surface water</sub>
Acute endangered species	$\geq 0.05$	Acute RQ <sub>surface water</sub>
Chronic risk	$> 1$	Chronic RQ <sub>surface water</sub>

Currently, EFED has no procedures for assessing chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species. Other values may be used when justified.

**c. Exposure and Risks to Nontarget Terrestrial Animals**

**(1) Birds, Reptiles and Terrestrial-Phase of Amphibians**

The risks to birds from the use of fenamiphos at a given use site and at registered application rates and methods are calculated in this section. In this risk assessment risks to birds are also used as a measure of risks to reptiles and terrestrial-phase amphibians.<sup>29, 30, and 31</sup> The risks to birds from the emulsifiable concentrate formulation of fenamiphos, Nemacur 3, are provided in Section 5c(1)(a) and the risks from the granular end-use formulations of fenamiphos, Nemacur 10G and 15G, are provided in Section 5c(1)(b).

**(a) Risks from Fenamiphos Residues on Plants and Insects**

**Risks from Parent Fenamiphos.** Maximum and mean acute and chronic RQs for exposure attributable to fenamiphos residues on plants and insects are tabulated in Table G1 for all registered Nemacur 3 uses (apple, asparagus, citrus, cotton, eggplant, grapes, kiwi fruit, peanuts, pineapple, raspberry, stone fruits, strawberry, table beets, tobacco, and turf). A summary of avian RQs calculated for nonturf uses at single application rates of 1.2 to 9.0 lbs a.i./A and turf uses at the single application rate of 9.9 lbs of a.i./A are provided in Table 17. *All registered nonturf and turf application uses and rates resulted in exceedances of acute risk, restricted risk, and endangered species and chronic LOCs to birds, reptiles, and terrestrial-phase amphibians.*

<sup>29</sup> OPP Corn Cluster Document, A Special Review of 4 Corn Insecticides, Chapter 7, pages 148-149, April 1994. (Toxicity testing using bird test species as surrogates and indicators of the pesticide's toxicity to reptiles and terrestrial-phase amphibians and freshwater fish as surrogates and indicators of the pesticide's toxicity to aquatic-phase amphibians.)

<sup>30</sup> Tucker, R.K., and J.S. Leitzke, Comparative Toxicology of Insecticides for Vertebrate Wildlife and Fish, *Pharmacology Ther.*, Vol. 6, pp. 167-220, 1979.

<sup>31</sup> Suter, G.W., *Pesticide Effects on Terrestrial Wildlife*, L. Somerville and C.H. Walker, Eds., Taylor & Francis, New York, 1990.

**Table 17. Summary of Avian RQs Calculated for Residues of Fenamiphos on Plants and Insects from Nemacur 3 Uses**

Residue Level	Application Rate (lb a.i./A)	Acute RQs		Chronic RQs	
		Fruits, pods, seeds, and large insects <sup>a</sup>	Short grass <sup>a</sup>	Fruits, pods, seeds, and large insects <sup>a</sup>	Short grass <sup>a</sup>
Nonturf crops					
Maximum	1.2	0.5	7.8	9.0	144
	9.0	3.6	>57	68	>1,080
Mean	1.2	0.22	1.5	4.2	22
	9.0	1.7	>20	32	>382
Turf					
Maximum	9.9	3.9	63	74	1,188
Mean	9.9	1.8	22	7.0	421

LOC exceedances are indicated by shaded areas.

<sup>a</sup>RQs were calculated for four categories of food items, the ones presented here provide the low-end and high-end RQ range.

The Nemacur 3 label allows multiple applications on citrus, pineapple, and strawberry. The quantifiable risks to terrestrial vertebrates resulting from exposure to fenamiphos residues on plants and insects from additional applications which are applied at intervals of greater than two days are assumed to be identical to that quantified for single applications as fenamiphos surface residues are expected to rapidly degrade via photolysis (half-life of 3.23 hours) on exposed plants and insects.

#### (b) Risks from Granular Fenamiphos Residues on the Soil Surface

The risk to birds posed from applications of granular formulations of fenamiphos, Nemacur 10G and 15G, are calculated in this Section. Terrestrial vertebrates may be exposed to pesticides applied to soil by ingesting pesticide granules and/or pesticide-treated soil when foraging. Rich in minerals, soil comprises 5-to-30% of dietary intake by many wildlife species.<sup>32</sup> For the screening risk assessment, risks were calculated for a representative size range of birds (20, 180, and 1000 grams). Obviously this range is not inclusive as there are a number of birds smaller than 20 grams such as hummingbirds (~3 grams), chickadees (10 to 12 grams), bushtits (~ 5 grams), and creepers (~9 grams) and a number of birds larger than 1,000 grams such as the Great Blue Heron (2,500 grams), the Wild Turkey (4,200 to 7,400 grams), and the Canada Goose (1,600 to 4,500 grams).

Avian acute RQs/ft<sup>2</sup> for each registered use of Nemacur 10G and 15G (anthurium; bananas; bok choy; brussel sprouts; cabbage; cotton; eggplant; garlic; iris, lily and narcissus bulbs; leatherleaf fern; non-bearing strawberries; non-bell peppers; peanuts; pineapple; nursery stock; okra; plantains; strawberries; and turf) are provided in Table G2. A summary of the acute avian RQs/ft<sup>2</sup> due to exposure to fenamiphos from granular applications of Nemacur 10G and 15G are provided in Table 18. *All registered turf and nonturf crop applications resulted in RQs/ft<sup>2</sup> exceeding acute risk, restricted use, and endangered species LOCs. For a given use of fenamiphos, risk increases with decreasing size of the exposed bird receptors.*

<sup>32</sup>

W. N. Beyer and E.E. Connor, "Estimates of Soil Ingestion by Wildlife," U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center at Laurel, MD and S. Gerould, U.S. Geological Survey, Reston, VA.

**Table 18. Summary of Acute Avian RQs from Exposure to Granular Nemacur Applications**

Application Method	Application Rate (mg a.i./ft <sup>2</sup> )	Percent Incorporated	Acute RQs/ft <sup>2</sup> for Body Weight (grams) of:		
			20	180	1,000
Nonturf Crops					
Incorporated	70.8 <sup>a</sup> , 782 <sup>b</sup>	99	22 <sup>a</sup> , 245 <sup>b</sup>	2 <sup>a</sup> , 27 <sup>b</sup>	0.4 <sup>a</sup> , 5 <sup>b</sup>
Partial Incorporation	51 to 93.7	85	239 to 439	27 to 49	5 to 9
Turf and Ornamentals					
Iris, lily, and narcissus bulbs, partial Incorporation	363	85	1,701	189	34
Turf, leatherleaf fern, anthurium and nursery stock unincorporated	104	0	3,254	362	65

Shaded RQ values exceed OPP's LOCs.

<sup>a</sup>Applied to established plantings of bananas and plantains.

<sup>b</sup>Applied to garlic at planting.

Balcomb et al. (1984) found that 40 and 60% mortality occurred in Red-winged Blackbirds when dosed with 5 and 10 granules of Nemacur 10G, respectively. For registered Nemacur 10G and 15G uses, application rates and methods, the number of granules of fenamiphos that are estimated to be available on the surface for birds to forage ranges from 54 to 11, 966 granules/ft<sup>2</sup> (Table G2). The number of granules that are equivalent to an LD<sub>50</sub> for the Bobwhite Quail, Mourning Dove, and several passerine birds are provided in Table 19. *All uses, application methods and rates result in more than enough granules in any given square foot of treated area to result in several birds obtaining doses greater than the LD<sub>50</sub>.*

**Table 19. Number of 10 and 15G Fenamiphos Granules Equivalent to the LD<sub>50</sub> for Six Avian Species**

Species	Body Weight (grams)	LD <sub>50</sub> mg/Animal	No. Nemacur 15G Granules	No. Nemacur 10G Granules
Bobwhite	200	3	37	55
Robin	80	1	14	22
Mourning Dove	100	2	18	28
House Sparrow	20	0.3	4	6
Redwing Blackbird	50	0.8	9	14
Grasshopper Sparrow	14	0.2	2	4

## (2) Mammalian Wildlife

### (a) Risks from Fenamiphos Residues on Plants and Insects

**Risks from Parent Fenamiphos.** For the screening risk assessment risks were calculated for a representative size range of mammalian receptors (15, 35, and 1000 grams). On a body weight basis, granivores consume per day less of their body weight than herbivores and insectivores, therefore separate RQs were calculated for the granivores from the herbivores and insectivores. Mammalian herbivore and insectivore RQs were calculated using the same consumption rates which were 95, 66 and 15% of body weight for 15, 35, and 1000 gram animals, respectively. Mammalian granivore RQs were calculated just for the seed (grain) category using body consumption rates of 21, 15, and 3% for 15, 35, and 1000 gram animals, respectively.

Maximum and mean acute and chronic RQs for exposure attributable to fenamiphos residues on plants and insects are tabulated in Table G3 for all registered Nemacur 3 uses (apple, asparagus, citrus, cotton,

eggplant, grapes, kiwi fruit, peanuts, pineapple, raspberry, stone fruits, strawberry, table beets, tobacco, and turf). A summary of mammalian RQs calculated for nonturf uses at single application rates of 1.2 to 9.0 lbs a.i./A and turf uses at the single application rate of 9.9 lbs of a.i./A are provided in Table 20. *All registered nonturf and turf application uses and rates resulted in exceedances of acute risk, restricted use, and endangered species and chronic risk LOCs to mammalian wildlife.*

**Table 20. Summary of Mammalian RQs Calculated for Residues of Fenamiphos on Plants and Insects from Nemacur 3 Uses**

Residue Level	Application Rate (lbs a.i./A)	Acute RQs <sup>a</sup> for Small to Medium Sized Mammals (15, 35, 1000 grams)						Chronic RQs	
		Fruits, pods, seeds, and large insects <sup>b</sup>			Short grass <sup>b</sup>			Fruits, pods, seeds, and large insects <sup>b</sup>	Short grass <sup>b</sup>
		15	35	1,000	15	35	1,000		
<i>Nonturf crops</i>									
Maximum	1.2	7.2 (1.6) <sup>c</sup>	5.0 (1.1)	1.1 (0.2)	115	80	18	7.2	115
	9.0	54 (12)	37 (8.5)	8.5 (1.7)	>862	>599	>136	54	864
Mean	1.2	3.4 (7.0)	2.3 (5.0)	0.52 (0.1)	47	28	6.4	3.4	48
	9.0	25 (5.6)	17 (4.0)	4.0 (0.8)	305	212	48	25	306
<i>Turf</i>									
Maximum	9.9	59 (13)	41 (9.4)	9.4 (1.9)	948	656	150	59	950
Mean	9.9	36 (8.0)	25 (5.7)	5.7 (1.1)	579	402	91	36	580

LOC exceedances are indicated by shaded areas.

<sup>a</sup>Acute RQs for the fruit, pod, seed, and large insect category were calculated separately for mammalian herbivores, insectivores and granivores. Ranges for granivores are provided in parentheses.

<sup>b</sup>RQs were calculated for four categories of food items, the ones presented here provide the low-end and high-end RQ range.

**Risks from the Major Environmental Degradates.** Acute risks to mammals could not be calculated for the major environmental degradate fenamiphos sulfoxide because there are no mammalian acute toxicity data. Additionally, chronic risks for the two major environmental degradates, fenamiphos sulfoxide and fenamiphos sulfone were not calculated because there is no mammalian chronic toxicity data. Because these degradates are expected to have the same mode of action as the parent compound, risks to the parent compound and the major degradates are likely to be at least additive.

Maximum and mean EEC values on plants and insects were calculated from fenamiphos EECs (Table E1) assuming a conversion rate from parent fenamiphos to fenamiphos sulfone of 3.5%. Resulting maximum and mean acute RQs for ingestion of fenamiphos sulfone residues on plants and insects are provided for each Nemacur 3 use in Table G4. A summary of mammalian RQs calculated for nonturf uses at single fenamiphos application rates of 1.2 to 9.0 lbs a.i./A and turf uses at the single application rate of 9.9 lbs of a.i./A are provided in Table 21 for fenamiphos sulfone.

Although the fenamiphos sulfone is as toxic as the parent compound, fenamiphos sulfone RQs were lower than for the parent compound; this is attributable to the lower exposure concentration estimated to occur for this degradate (i.e., 3.5% of parent). *Despite the lower RQs for the degradate, all registered nonturf and turf application uses and rates resulted in exceedances of acute risk, restricted use, and endangered species LOCs to mammalian wildlife.* The highest estimated risks are associated with small mammals that feed upon grass. Acute risks to certain segments of mammalian wildlife were not exceeded, such as large mammalian granivores at the application rate of 1.2 lbs a.i./A (peanuts with 72-inch, double row spacing).

**Table 21. Summary of Mammalian RQs Calculated for Residues of Fenamiphos Sulfone on Plants and Insects from Nemacur 3 Uses**

Residue Level	Nemacur 3 Application Rate (lbs a.i./A)	Acute RQs <sup>a</sup> for Small to Medium Sized Mammals (15, 35, 1000 grams)							
		Fruits, pods, seeds, and large insects <sup>b</sup>				Short grass <sup>b</sup>			
		15	35	1,000	15	35	1,000		
Nonturf crops									
Maximum	1.2	0.24	(0.05)	0.17	(0.04)	0.04 (<0.01)	4.0	2.8	0.6
	9.0	1.7 (0.21)		1.2 (0.15)		0.3 (0.03)	28	19	4.4
Mean	1.2	0.12	(0.03)	0.08 (0.02)		0.02 (<0.01)	1.4	1.0	0.23
	9.0	0.8 (0.18)		0.6 (0.13)		0.1 (0.03)	9.8	6.8	1.5
Turf									
Maximum	9.9	2.1 (0.46)		1.4 (0.33)		0.33 (0.06)	32	23	5.2
Mean	9.9	1.3 (0.28)		0.9 (0.2)		0.2 (0.04)	20	14	3.2

LOC exceedances are indicated by shaded areas.

<sup>a</sup>Acute RQs for the fruit, pod, seed, and large insect category were calculated separately for mammalian herbivores, insectivores and granivores. RQ values for granivores are provided in parentheses.

<sup>b</sup>RQs were calculated for four categories of food items, the ones presented here provide the low-end and high-end RQ range.

### (b) Risks from Granular Fenamiphos Residues on the Soil Surface

Mammals may also be exposed to pesticides applied to soil by ingesting pesticide granules and/or treated-soil when foraging. For the screening risk assessment, risks were calculated for a representative size range of mammals (15, 35 and 1000 grams). Mammalian acute RQs/ft<sup>2</sup> for each registered use of Nemacur 10G and 15G (anthurium; bananas; bok choy; brussel sprouts; cabbage; cotton; eggplant; garlic; iris, lily and narcissus bulbs; leatherleaf fern; non-bearing strawberries; non-bell peppers; peanuts; pineapple; nursery stock; okra; plantains; strawberries; and turf) are provided in Table G5. A summary of the acute avian RQs/ft<sup>2</sup> due to exposure to fenamiphos from granular applications of Nemacur 10G and 15G are provided in Table 22. ***All registered turf and nonturf crop applications resulted in RQs/ft<sup>2</sup> exceeding acute risk, restricted use, and endangered species LOCs.*** For a given use of fenamiphos, risk increases with decreasing size of the exposed mammalian receptor.

**Table 22. Summary of Acute Mammalian RQs from Exposure to Granular Nemacur Applications**

Application Method	Application Rate (mg a.i./ft²)	Percent Incorporated	Acute RQs/ft² for Small to Medium Size Mammals (15, 35, and 1000 grams)		
			15	35	1,000
Nonturf Crops					
Incorporated	70.8 <sup>a</sup> , 782 <sup>b</sup>	99	20 <sup>a</sup> , 219 <sup>b</sup>	9 <sup>a</sup> , 94 <sup>b</sup>	0.3 <sup>a</sup> , 3 <sup>b</sup>
Partial Incorporation	51 to 93.7	85	214 to 394	92 to 169	3 to 6
Turf and Ornamentals					
Iris, lily, and narcissus bulbs, Partial Incorporation	363	85	1,525	653	23
Turf, leatherleaf fern, anthurium and nursery stock Unincorporated (watered-in)	104	0	2,917	1,250	44

Shaded RQ values exceed OPP's LOCs.

<sup>a</sup>Applied to established plantings of bananas and plantains.

<sup>b</sup>Applied to garlic at planting.



### (3) Birds and Mammals, Simulated and Actual Field Exposure Studies

Bird and mammal simulated and actual field tests are required on a case-by-case basis depending on the results of laboratory acute and subacute toxicity tests, intended use pattern and pertinent environmental fate characteristics and predicted environmental risks. The standard screening level risk assessment indicates that all crop uses at current labeled application rates and methods are expected to result in acute and chronic impacts to terrestrial wildlife. The highest RQs are associated with granular broadcast treatment on turf and pineapples and emulsifiable treatment on turf, pineapples, tobacco, and citrus. Simulated and actual field exposure tests have been conducted for these crops and on bare ground; a list of simulated and actual field exposure studies which have been performed are provided in Table 23. A more detailed description and evaluation of the studies are provided in Appendix C. The submitted field studies had many deficiencies which limit or totally negate their use for evaluating the magnitude of impacts to terrestrial and aquatic wildlife from use of fenamiphos. Additionally, no field exposure reproductive or developmental studies were performed which limits the evaluation to acute impacts. However, the findings of the various studies do support that acute mortalities occur not only in birds but in mammals, amphibians and reptiles at current labeled rates.

**Table 23. Simulated and Actual Terrestrial Field Exposure Studies Using Nemacur 3, 10G, and 15G**

Surrogate Species/ Study Duration /Formulation	% a.i.	Application Rates (lbs a.i./A)	NOAEL Endpoints	LOAEL Endpoints	MRID No. Author/Year	Study Classification
Northern Bobwhite Quail ( <i>Colinus virginianus</i> )/ 14-Day Simulated field/ Nemacur 3	35	6, 10, and 20 (bare ground incorporated 2 to 3 inches)	No effect on weight gain, clinical signs of toxicity, gross lesions, or brain cholinesterase activity detected.	Mortality (effects limited to day of application)	121291 & 121292 /ACC 071291 D. W. Lamb & M. A. Carsel/1982	Supplemental
Mixed avian and mammalian species 41-Day Actual field study/ Apple and Cherry Orchards/ Nemacur 3	35	23.8	---	Mortality (acute effects observed for 5 days post application at which time it rained [0.9 inches] and no further mortalities were observed)	121293/ACC 071291 S. C. Carlisle/ D. W. Lamb/1982	Supplemental
Mixed avian species/ Actual field studies/ Six golf course sites/ Nemacur 10G	10	label rates	---	Mortality, loss of balance, outstretched wings, tucking the head inward, limping, salivating	41012902/Mobay Chemical Company 1988	Supplemental
Vertebrate species/ Actual field study/ Tobacco/ Nemacur 3	35	6 (ground sprayed followed by soil incorporation)	---	Mortality	42029903, 42029904 & 42029905/Mobay Chemical Company 1989-1990	Supplemental
Vertebrate species/ Actual field study/ Citrus grove/ Nemacur 15G	15	20	---	Mortality (Depressed cholinesterase levels in approximately one-third of avian population for about 30 days post- treatment)	4029901, 42029902/Mobay Chemical Company	Supplemental

**Table 23. Simulated and Actual Terrestrial Field Exposure Studies Using Nemacur 3, 10G, and 15G**

Surrogate Species/ Study Duration /Formulation	% a.i.	Application Rates (lbs a.i./A)	NOAEL Endpoints	LOAEL Endpoints	MRID No. Author/Year	Study Classification
Rice Bird( <i>Lonchura punctulata</i> ) Ring-necked Pheasant ( <i>Phasianus colchicus</i> )/ 14-day Simulated field study/ Pineapple field/ Nemacur 3	35	5 (watered-in 250 gallons per acre)	No significant behavioral deficits, weight decrease or cholinesterase decrease  No significant increase in mortality in Ring- necked Pheasants	Mortality – Rice Bird	ACC 120301/ Lamb & Nelson/ 1971	Supplemental
Rice Bird( <i>Lonchura punctulata</i> ) Ring-necked Pheasant ( <i>Phasianus colchicus</i> )/ 14-day Simulated field study/ Pineapple field/ Nemacur 15G	15	40 (416 mg a.i./ft <sup>2</sup> ) (incorporated 4 to 6 inches)	No significant behavioral deficits, weight decrease or cholinesterase decrease	Mortality	ACC 120301/ Lamb, Mcleod & Zeck/ 1971	Supplemental
English Sparrow ( <i>Passer domesticus</i> ) Bobwhite Quail ( <i>Colinus virginianus</i> ) New Zealand rabbit (species unknown)/ Simulated field study/ Nemacur 15G	15	20 (watered-in versus not watered-in – 2 rain events also occurred during the study)	Weight gain	Mortality and weight loss	ACC 120301/ Lamb & Jones/ 1972	Supplemental
Mixed avian species/ Citrus groves Florida's Central Ridge/ Actual field study/ Nemacur 3	35	(chemigation)		Mortality, blood cholinesterase	43737901	Supplemental
Mixed avian/ Six golf courses/ Actual field study/ Nemacur 10G	10	10		Mortality		Supplemental

#### d. Exposure and Risks to Nontarget Freshwater Animals

The risks to nontarget freshwater animals from the use of Nemacur products on the large acreage crops (cotton, grapes, peanuts, stone fruits, and tobacco), turf, high-end application rate ornamentals (i.e., leatherleaf fern), and the SLN non-bell peppers were calculated for registered application rates and methods; risks to freshwater fish are addressed in Section 5d(1) and to freshwater invertebrates in Section 5d(2).

##### (1) Risks to Freshwater Fish

Maximum and mean acute and chronic RQs for exposure attributable to fenamiphos runoff into surface water from large acreage crops, turf, high-end application rate ornamentals and the SLN non-bell peppers are tabulated in Table 24. For non-turf and non-ornamental uses, acute and chronic RQs for freshwater fish range from 0.8 to 31 and from 1.2 to 50, respectively. Acute and chronic RQs for freshwater fish are 86 and 103, respectively for high-end ornamental applications and 93 and 156, respectively, for turf use. *All evaluated uses and rates resulted in exceedances of acute risk, restricted use, and endangered species, and chronic LOCs for freshwater fish and therefore, aquatic-phase amphibians.*

**Table 24. Acute and Chronic RQs for Freshwater Fish (and Aquatic-Phase Amphibians)<sup>a</sup> and Invertebrates<sup>b</sup> for Single Applications of Nemacur 3 or 15G**

Crop/Formulation	Max Single Application Rate (lbs a.i./A)	Max Seasonal Application Rate (lbs a.i./A)	Fenamiphos Surface Water EEC (ppb)			Freshwater Fish RQs		Freshwater Invertebrate RQs	
			Acute	21-day	60-day	Acute	Chronic <sup>c</sup>	Acute	Chronic <sup>d</sup>
Cotton/ Nemacur 3	3.0	Not always specified but assumed 3.0	298	259	190	31	50	157	2,158
Grapes/Nemacur 3	6.0	6.0	67	58	43	7.1	11	35	482
Peanuts/ Nemacur 15G	2.6 (1.2) <sup>e</sup>	Not specified but assumed 2.6	7.9	6.6	4.5	0.8	1.2	4.2	55
Peaches	7.5	7.5	30	25	19	3.1	5.1	16	212
Tobacco/ Nemacur 3	6.0	Not specified but assumed 6.0	16	14	9.9	1.7	2.6	8.6	116
Leatherleaf Fern/ Nemacur 10G	10	Not specified, but assumed 10	820	622	393	86	103	432	5,183
Non-bell Peppers (CA, GA, and PR only)/ Nemacur 15G	2.0	Not specified, but assumed 2.0	88	77	59	9	16	46	638
Turf/ Nemacur 10G & 3	10	20	881	765	591	93	156	464	6,375

Shaded values exceed OPP's LOCs.

<sup>a</sup>Acute and chronic RQs are based on a Bluegill Sunfish LC<sub>50</sub> of 9.5 ppb and Rainbow Trout NOEC of 3.8 ppb, respectively.

<sup>b</sup>Acute and chronic RQs are based on a *Daphnia magna* LC<sub>50</sub> of 1.9 and NOEC of 0.12 ppb, respectively.

<sup>c</sup>Chronic exposure for the fish is based on the 60-day EEC.

<sup>d</sup>Chronic exposure for the invertebrate is based on the 21-day EEC.

<sup>e</sup>Peanuts: The first and second set of values represent 36-inch, single-row, and 72-inch, double-row bed spacing, respectively.

##### (2) Risks to Freshwater Invertebrates

Maximum and mean acute and chronic RQs for exposure attributable to fenamiphos runoff into surface water from large acreage crops, turf, high-end application rate ornamentals and the SLN non-bell peppers are tabulated in Table 24. For non-turf and non-ornamental uses, acute and chronic RQs for freshwater invertebrates range from 4.2 to 157 and from 55 to 2158, respectively. Acute and chronic RQs for freshwater invertebrates are 432 and 5183, respectively for high-end ornamental applications and 464 and

6375, respectively, for turf use. *All evaluated uses and rates resulted in exceedances of acute risk, restricted use, and endangered species LOCs for freshwater invertebrates.*

### (3) Exposure and Risks to Nontarget Estuarine and Marine Animals

Acute RQs for estuarine/marine invertebrates exposed to runoff from large acreage crops, turf, high-end application rate ornamentals, and non-bell peppers are provided tabulated in Table 25. For non-turf and non-ornamental uses, the acute RQs for estuarine/marine invertebrates range from 4.8 to 48. Acute RQs for high-end ornamental applications is 132 and is 142 for turf use. *All evaluated uses and rates resulted in exceedances of acute risk, restricted use, and endangered species LOCs for estuarine/marine invertebrates.* Although required, chronic data have not been submitted and therefore chronic RQ values cannot be determined at this time.

**Table 25. Acute RQs for Estuarine/Marine Invertebrates for Single/Multiple Applications of Nemacur 3 or 15G Based on a Mysid Shrimp LC<sub>50</sub> of 6.2 ppb.**

Crop/Formulation	Maximum Single Application Rate (lbs a.i./A)	Maximum Seasonal Application Rate (lbs a.i./A)	Acute Concentration (ppb)	Acute RQ
Cotton/Nemacur 3	3.0	Not Always Specified But Assumed 3.0	298	48
Grapes/Nemacur 3	6.0	6.0	67	11
Peanuts/ Nemacur 15G	2.6 (1.2) <sup>a</sup>	Not Specified But Assumed 2.6	7.9	1.3
Peaches	7.5	7.5	30	4.8
Tobacco/Nemacur 3	6.0	Not Specified But Assumed 6	16	2.6
Leatherleaf Fern/Nemacur 10G	10	Not Specified But Assumed 10	820	132
Non-bell Peppers (CA, GA, and PR only)/Nemacur 15G	2.0	Not Specified But Assumed 2.0	88	14
Turf/Nemacur 10G & 3	10	20	881	142

<sup>a</sup>Peanuts: The first and second sets of values represent 36-inch, single-row, and 72-inch, double-row bed spacing, respectively.

### (4) Freshwater Simulated and Field Exposure Studies

Aquatic simulated and actual field tests are required on a case-by-case basis depending on the results of laboratory toxicity tests, intended use pattern, pertinent environmental fate characteristics and results of the aquatic risk assessment. Additionally, a registrant may want to conduct a study to try and demonstrate that modifying factors in the field reduces the magnitude of predicted risks to acceptable levels.

Results from a simulated field exposure study (mesocosm) and a tobacco field study are briefly described below. The findings of the mesocosm study support the risk assessment findings that fenamiphos poses acute risks to the integrity and animals of the aquatic community.

**Mesocosm Study.** A simulated field study which utilized an artificial pond system (mesocosm) to assess the potential for ecological and biological effects resulting from fenamiphos was submitted for review. The study used a series of 12 ponds. The test animals were fish and aquatic invertebrates. Zooplankton, macroinvertebrates and fish were identified to genus and quantified for number and species richness prior to exposure. The dosing regime was 1.0, 3.5 and 12.5 ppb. The zooplankton groups were affected by Nemacur at the 12.5 ppb level. The primary effects were population declines in several species of rotifers and an increase in copepoda. Macroinvertebrates were most affected both in species number and richness at the 3.5 and 12.5 ppb levels. The two orders most negatively affected were Ephemeroptera (mayflies) and Trichoptera (caddisflies). No acute effects were observed in the adult fish at the 1.0 and 3.5 ppb

levels; however, within 24 hours of application, acute effects were observed at the 12.5 ppb in both adult and young fish. Species number and richness declined. In addition, by study completion, statistically significant increases in weight and length of fish surviving occurred, due perhaps to reduced competition for available food and other resources.

Based on these results adverse ecological effects to aquatic organisms will occur if the use of fenamiphos results in exposure levels greater than 3.5 ppb. As indicated in the Water Resources section of this document, estimated acute EEC values range from 6.5 to 651 ppb, a level 1.7 to 171 times greater.

The physio-chemical parameters of the water such as dissolved oxygen, temperature, pH, alkalinity, hardness, total suspended solids, organic carbon and nitrogen, were, generally, unchanged by the Nemacur application. Turbidity appeared to be lower in the treatment ponds than in the controls. This guideline study (72-7a) was scientifically sound and conducted in accordance with good laboratory practice (MRID 42029906).

**Nemacur 3 Use on Tobacco, Incorporation of Remote Sensing/GIS Evaluation into an Aquatic Exposure Assessment.** Although the submitted study does not represent all tobacco growing areas, the GIS/Remote Sensing approach taken by the author has merit. Using the “windshield survey”, the data submitter attempted to reduce many uncertainties associated with geographic information systems such as positional inaccuracy, sampling and scale.

However the following should also be considered:

The Remote Sensing/GIS evaluation took into account only lentic water bodies with dimensions of these water bodies calculated only during the month of July. The remote sensing results should have been captured instead at two different time periods and overlaid for comparative results: the first snapshot should have been when Nemacur 3 is surface broadcast to the tobacco field and “disked in” in order to capture peak surface-area measurements of surrounding ephemeral and nonephemeral streams and lentic bodies, and the second snapshot should be when tobacco is at maturity, to identify where tobacco was grown. This approach would better quantify the number and total area of water bodies that could be potentially affected by pesticides applied on a tobacco crop in Wayne County, North Carolina.

**e. Exposure and Risks to Nontarget Plants**

Nemacur labels bear phytotoxicity warnings which suggest that fenamiphos is toxic to plants. RQs could not be calculated because toxicity data for plants has not been submitted. The potential for acute risks to non-endangered, endangered or threatened terrestrial, semi-aquatic and aquatic plants exposed to fenamiphos at use sites is unknown. EFED is presently requesting plant data to determine its toxicity in order to assess the risks to terrestrial, semi-aquatic and aquatic plants. Currently, EFED does not perform chronic risk assessments for terrestrial and semi-aquatic plants.

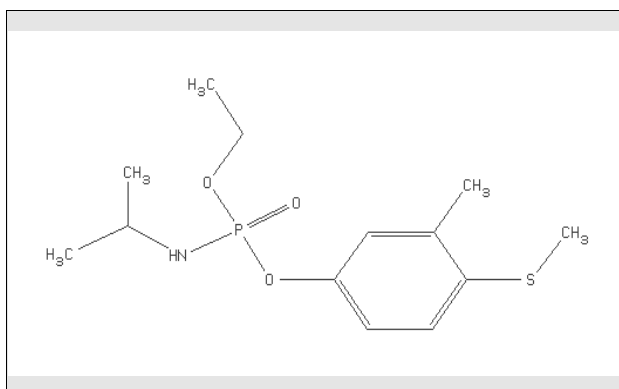
**f. Exposure and Risks to Endangered Species**

*At current registered rates and uses, endangered species LOCs are exceeded for all terrestrial and aquatic organisms for all current uses.*

**APPENDIX A: Chemical Profile for Fenamiphos**

Common name	fenamiphos, Nemacur
CAS Number	22224-92-6
Chemical name	ethyl 3-methyl-4-(methylthio)phenyl (1-methylethyl)phosphoramidate

Structure

**Figure 1.** Molecular structure of fenamiphos.

Molecular formula	C <sub>13</sub> H <sub>22</sub> PSNO <sub>3</sub>
Molecular weight	303.36
Henry's Law Constant	1.0 X 10 <sup>-9</sup> atm.*m <sup>3</sup> /mol
Vapor pressure	1.3 X 10 <sup>-6</sup> Torr
Solubility at 20 °C	400 mg/L in water soluble in most organic solvents



## APPENDIX B: Fenamiphos Use Profile with Label Conversions

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Fenamiphos is an organophosphate which is applied primarily to control plant-parasitic nematodes and to secondarily control certain insects. Fenamiphos is highly water soluble (400,000 ppb) and is readily taken up and translocated throughout a plant. Fenamiphos is sold under the trade name, Nemacur. Three end-use formulations are registered: Nemacur 10% Granular Turf and Ornamental Nematicide (Nemacur 10G), Nemacur 3 Turf Nematicide or Nemacur 3 Emulsifiable Systemic Insecticide-Nematicide (Nemacur 3), and Nemacur 15% Granular Systemic Insecticide-Nematicide.

**Nemacur 10% Granular Turf and Ornamental Nematicide.** According to the February 13, 1997 notification label, Nemacur 10G is to be used to control nematodes in turf grasses located in golf courses, cemeteries, sod farms, and industrial grounds; in ornamentals such as iris, lily, narcissus, leatherleaf fern, protea, and anthurium; and in nursery stock. In California, Nemacur 10G is registered only for use to control nematodes in turf grasses, golf courses, and sod farms.

**Nemacur 15% Granular Systemic Insecticide-Nematicide.** According to the September 12, 1996 USEPA stamped acceptable with comments label, Nemacur 15G is to be used primarily for the control of nematodes on certain field, fruit (strawberries, pineapple [in Puerto Rico]), and vegetable crops (bok choy [California only], cabbage, transplanted brussel sprouts [except cabbage and brussel sprouts grown for seed], eggplant, okra [except in California], non-bell peppers [in California, Georgia and Puerto Rico]), and non-bearing strawberry nursery stock. On cotton and peanuts Nemacur 15G is also applied to control thrips. On garlic Nemacur 15G is applied to control bulb and stem nematodes.

There is also a Special Local Need Registration Label, dated March 17, 1997 for use on bananas and plantains.

**Nemacur 3 Emulsifiable Systemic Insecticide-Nematicide.** According to the December 6, 1996 notification label, Nemacur 3 is to be used to control nematodes and certain insects in field, fruit and vegetable crops. Nemacur 3 is applied to control nematodes in stone fruit tree (apple, cherry, nectarine, and peach) and kiwi orchards, strawberries, raspberries (except in California), eggplants, asparagus (in Connecticut, Delaware Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Rhode Island). Nemacur 3 is applied to table beets (in Illinois, Indiana, Michigan, New York, Ohio and Pennsylvania) to control cyst nematodes. It is applied to grapes to control nematodes and suppress *Phylloxera*. It is applied to cotton to control nematodes and thrips. For tobacco, Nemacur 3 is

applied to control nematodes (except tobacco cyst) and suppress aphids; additionally when mixed with Lorsban 4 to control cutworms, flea beetles, wire worms, and mole crickets. On citrus (except kumquat, tangelo, or citrus hybrids in California), Nemacur 3 is applied to control nematodes and the citrus root weevil complex including fuller rose beetle suppression. In Hawaii and Puerto Rico, Nemacur 3 is used on pineapples to control nematodes.

According to a November 8, 1995 USEPA Stamped Accepted label, Nemacur 3 can be applied to turf using a uniform distribution over treatment area with ground spray equipment with a coarse-spray nozzle directed at the turf surface to control for nematodes. The label indicates to irrigate the treated area immediately following application, applying a minimum of 0.5 inches of water to move the product into the soil with the total irrigation complete within 6 hours of application. The label indicates that irrigation should be applied in a manner not to result in puddling or runoff.

**Application Rates.** Application rates for Nemacur 3, 10G and 15G used in the risk assessment were obtained from registered labels. The risk assessment methods used within this document require application rates to be expressed in terms of lbs a.i./A. Therefore, label rates not expressed as lbs a.i./A needed to be converted. The conversions used are provided in this Appendix and label rates in terms of lbs a.i./A are provided for each registered use in Tables B1 through B8.

For crops (e.g., bok choy, brussel sprouts, cabbage, cotton, eggplant, garlic, iris, lily, narcissus, non-bell peppers, okra, peanuts, strawberries, and table beets) where the application rate is by linear feet of row either as lbs/1000 ft of row (Table B5), dry ounces/1000 ft of row (Table B8) or fluid ounces/1000 ft of row (Table B7), the distance between planting rows significantly influences the amount of pesticide applied per acre; the application rate in lbs a.i./A will increase as row spacing decreases. Therefore, unless the maximum lbs a.i./A for a given use was specified on the label, EFED calculated maximum and mean lbs a.i./A for a range of likely row spacings based on planting practices. Unless specified otherwise below, the maximum and highest mean lbs a.i./A for a given use was used to calculate exposure concentrations for a given crop scenario.

***Brussel Sprouts, Bok Choy, and Cabbage.*** In the western U.S., brussel sprout transplants, bok choy and cabbage are grown in beds with 2 rows per bed, each row spaced 20 inches apart, and each bed center 40 inches apart. In the eastern U.S., brussel sprout transplants, bok choy and cabbage are grown in single rows, spaced 24 to 30 inches apart.

***Cotton.*** Although cotton can be planted using various row spacings, a maximum rate of 3 lbs a.i./A regardless of row spacing is provided on the label and is therefore used to calculate maximum and mean residue EECs for cotton use (Table C1). However, conversions were made to verify that stated application rates were at or below 3 lbs a.i./A. Traditional cotton row spacing varies from a minimum of 36 inches to a maximum of 40 inches. Spacing width is predominately dependent on available soil moisture, soil type, planter equipment requirements and yield benefits. In the eastern U.S. rows tend to be closer together with single rows spaced 36 inches apart. As one travels west, row spacing width increases to 38-inches in the central U.S. to 40-inches in the arid southwest. Approximately 70% of the cotton grown in the U.S. is planted in single rows, spaced 40-inches apart. Approximately 28% is grown in single rows,

spaced 36 to 38 inches apart. Currently about 2% is genetically-engineered and is planted in ultra-narrow rows, spaced 7 to 10 inches apart.<sup>33</sup>

**Eggplant.** For eggplant, the acute and chronic EECs are based on a 2.0 lbs a.i./A rate, with 36-inch row spacing, as stated on the label. However, in Florida, where a large portion of the U.S. crop is grown, eggplants are staked in single rows with each row spaced 6 feet apart. Hence, the application rate and resulting EECs would be cut in half. Because, at this time, it is not known how much of the U.S. crop is grown at 36-inch versus 72-inch row spacing, the environmental risk assessment has been completed using the maximum exposure values that can be generated.

**Garlic.** For commercial production, garlic is grown as two seedlines per bed (scattered cloves in two linear rows). Each seedline is spaced 20- to 22-inches apart, and each bed center is 40-inches apart.<sup>34</sup>

**Iris, Lily, and Narcissus.** Although row spacing is variable, for the majority of commercial production bulbs are planted in 8-inch row bands, spaced 40 inches apart.<sup>35</sup> This is an in-furrow application before planting; however, if the plants are already established, it is banded (10- to 12-inch bands) on the top of the row then it is watered-in with at least 0.5 inch of water.

**Non-bell peppers.** Non-bell peppers are planted for commercial production in beds each containing two rows. Each bed row is spaced 20 inches apart, and each bed center 6 to 8 feet apart.<sup>36</sup>

**Okra.** In the U.S., 90% of the okra grown commercially is planted in single rows spaced 40 inches apart for dwarf; 48 inches apart for medium-tall; and 54 inches apart for tall varieties. Wide-row spacing is necessary because okra is harvested entirely by hand labor. The remaining 10% is planted with a two-row planter. Okra is commercially grown for fresh market in the southern part of the U.S. from northern Florida and southern Georgia stretching west to California.<sup>37</sup>

**Peanuts.** Peanuts are typically planted with the same equipment used to sow upland cotton; as a result, the pre-set 36- or 38-inch single-row spacing of upland cotton will dictate the row spacing for peanuts. Over 90% of the peanuts grown are planted in this manner. Less than 10% of the peanuts grown are planted in double-row beds, with 28 inches between the rows and 6 feet (72 inches) between bed centers. In Table C1, maximum and mean residue EECs are provided for peanuts planted at 36-inch, single-row spacing but are also provided for 72-inch bed centers, with double rows.

**Strawberries.** Commercially produced strawberries are planted in double-row beds, spaced 11 inches apart with 4 feet of spacing from bed center to bed center. The maximum single and seasonal application rates are 4.5 and 7.0 lb a.i./A.

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<sup>33</sup> Dr. Gus Lorenz, University of Arkansas, Cooperative Extension, Fayetteville, Arkansas and the 1996 National Agricultural Statistics Service Commodity Cropland Maps and Report.

<sup>34</sup> Dr. Edwards Kerst. California Garlic and Onion Association, and Dr. Vince Rubatzky, Horticultural Research and Information Center, University of California at Davis.

<sup>35</sup> William M. Roozen, Washington Bulb Company, Inc., 1599 Beaver Marsh Road, Mount Vernon, Washington 98273

<sup>36</sup> Dr. Vince Rubatzky, Horticultural Research, University of California at Davis.

<sup>37</sup> Dr. C.R. Andersen, Department of Horticulture, University of Arkansas at Fayetteville.

**Table Beets.** Table beets, grown in northern states, such as Michigan and New York, are seeded in clusters, which are spread over bands 4-inches wide, with each band of rows spaced 2 feet apart.<sup>38</sup> When grown in this fashion, the maximum single application rate is 3.1 lb a.i./A.

**Table B1. Conversion of lbs of Product/A to lbs a.i./A.**

Product	Fraction of a.i.	Use	Application Type	Product Rate (lbs/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 10G	0.1	Leather leaf fern	Maximum Single	100	10
Nemacur 10G	0.1	Nursery stock	Maximum Single	100	10
Nemacur 10G	0.1	Nursery stock	Maximum Seasonal	--	20
Nemacur 15G	0.15	Pineapple – Puerto Rico	Maximum Single	60	9
Nemacur 15G	0.15	Pineapple – Puerto Rico	Maximum Seasonal	--	18

<sup>a</sup>Conversion equation for lbs of product/A to lbs a.i./A.

$$z \frac{(\text{lbs a.i.})}{1(\text{A})} = x \frac{(\text{lbs of product})}{1(\text{A})} \times y \frac{(\text{lbs of a.i.})}{1(\text{lb of product})}$$

**Table B2. Conversion of lbs or Grams of Product/1,000 ft<sup>2</sup> to lbs a.i./A**

Product	Fraction of a.i.	Use	Application Type	ProductRate (lbs/1,000 ft <sup>2</sup> )	ProductRate (lbs/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 10G	0.1	Turf grasses	Maximum Single	2.3	100	10
Nemacur 10G	0.1	Turf grasses	Maximum Seasonal	--	200	20
Nemacur 10G	0.1	Protea	Maximum Single	1.0 to 2.3	44 to 98	4.4 to 10
Nemacur 10G	0.1	Protea	Maximum Seasonal	2.0 to 4.5	87 to 196	8.7 to 20
Nemacur 15G	0.15	Bananas and Plantains – SLN	Maximum Single	0.688 <sup>b</sup> to 1.0 <sup>b</sup>	30 to 45	4.5 to 6.7

<sup>a</sup>Conversion equation for lbs of product/1,000 ft<sup>2</sup> to lbs a.i./A

$$z \frac{(\text{lbs a.i.})}{1(\text{A})} = x \frac{(\text{lbs of product})}{1,000 (\text{ft}^2)} \times \frac{43,560 (\text{ft}^2)}{1 (\text{A})} \times y \frac{(\text{lbs of a.i.})}{1 (\text{lb of product})}$$

<sup>b</sup>Conversion equation for grams of product/64 ft<sup>2</sup> to lbs of product/1,000 ft<sup>2</sup>

$$\frac{x (\text{lbs of product})}{1,000 (\text{ft}^2)} = \frac{z (\text{grams of product})}{64 (\text{ft}^2)} \times \frac{1 (\text{kg})}{1,000 (\text{grams})} \times \frac{1 (\text{lb})}{0.454 (\text{kg})} \times 1,000$$

$$20 \text{ grams}/64 \text{ ft}^2 \times 1 \text{ kg}/1000 \text{ grams} \times 1 \text{ lb}/0.454 \text{ kg} \times 1000 = 0.688 \text{ lbs of product}/1,000 \text{ ft}^2$$

$$30 \text{ grams}/64 \text{ ft}^2 \times 1 \text{ kg}/1000 \text{ grams} \times 1 \text{ lb}/0.454 \text{ kg} \times 1000 = 1.032 \text{ lbs of product}/1,000 \text{ ft}^2$$

**Table B3. Conversion of Dry Ounces/1,000 ft<sup>2</sup> to lbs a.i./A.**

Product	Fraction of a.i.	Use	Application Type	Product Rate (oz/1,000 ft <sup>2</sup> )		Product Rate (lbs/A)		a.i. Rate (lbs/A) <sup>a</sup>	
Nemacur 10G	0.1	Anthurium	Maximum Single	18.3	to 36.7	49.8	to 99.9	5	to 10
Nemacur 10G	0.1	Anthurium	Maximum Seasonal	36.6	to 73.4	99.6	to 199.8	10.0	to 20

<sup>a</sup>Conversion equation for dry ounces (oz) of product/1000 ft<sup>2</sup> to lbs a.i./A.

$$\frac{\text{lbs a.i.}}{1(A)} = \frac{x (\text{dry oz of product})}{1,000 (\text{ft}^2)} \times \frac{1 (\text{lb})}{16 (\text{dry oz})} \times \frac{43,560 (\text{ft}^2)}{1 (A)}$$

**Table B4. Conversion of Gallons of Product/A to lbs a.i./A for Nemacur 3.**

Product	lbs a.i./gallon	Use	Application Type	Product Rate (gallons/A)		a.i. Rate (lbs/A) <sup>a</sup>	
Nemacur 3	3	Tobacco (broadcast)	Maximum Single <sup>b</sup>	1.33	to 2	4.0	to 6.0
Nemacur 3 with Lorsban 4 EC	3	Tobacco (broadcast with incorporation 2 to 4 inches)	Maximum Single <sup>b</sup>	1	to 2	3.0	to 6.0
Nemacur 3 with MoCap EC	3	Tobacco (broadcast with incorporation 2 to 4 inches)	Maximum Single <sup>b</sup>	1	to 2	3.0	to 6.0
Nemacur 3	3	Apple, Cherry, Nectarine and Peach (tree row band)	Maximum Single	1.66	to 2.5	5.0	to 7.5
Nemacur 3	3	Apple, Cherry, Nectarine and Peach (tree row band)	Maximum Seasonal	--			7.5
Nemacur 3	3	Apple, Cherry, Nectarine and Peach (low-pressure irrigation)	Maximum Single	1.0	to 2.0	3.0	to 6.0
Nemacur 3	3	Apple, Cherry, Nectarine and Peach (low-pressure irrigation)	Maximum Seasonal	--			6.0
Nemacur 3	3	Grapes (vine row band with incorporation)	Maximum Single	1.0	to 2.0	3.0	to 6.0
Nemacur 3	3	Grapes (vine row band with incorporation)	Maximum Seasonal	--			6.0
Nemacur 3	3	Grapes (low-pressure irrigation)	Maximum Single	1.0	to 2.0	3.0	to 6.0
Nemacur 3	3	Grapes (low-pressure irrigation)	Maximum Seasonal	--			6.0
Nemacur 3	3	Kiwi fruit (low-pressure irrigation), California only	Maximum Single	1.0	to 2.0	3.0	to 6.0
Nemacur 3	3	Kiwi fruit (low-pressure irrigation), California only	Maximum Seasonal	--			6.0
Nemacur 3	3	Citrus: except kumquat, tangelo or citrus hybrids in California; except Florida (tree band with incorporation)	Maximum Single	1.66	to 2.0	5.0	to 7.5
Nemacur 3	3	Citrus: except kumquat, tangelo or citrus hybrids in California; except Florida (tree band with incorporation)	Maximum Seasonal	--			7.5
Nemacur 3	3	Citrus: except kumquat, tangelo or citrus hybrids in California; except Florida (low-pressure irrigation)	Maximum Single	1.0	to 2.0	3.0	to 6.0

**Table B4. Conversion of Gallons of Product/A to lbs a.i./A for Nemacur 3.**

Product	lbs a.i./ gallon	Use	Application Type	Product Rate (gallons/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 3	3	Citrus: except kumquat, tangelo or citrus hybrids in California; except Florida (low-pressure irrigation)	Maximum Seasonal	--	6.0
Nemacur 3	3	Citrus: for specific Florida counties <sup>c</sup> (tree band)	Maximum Single	0.833 to 1.66	2.5 to 5.0
Nemacur 3	3	Citrus: for specific Florida counties <sup>c</sup> (tree band)	Maximum Seasonal	--	10.0
Nemacur 3	3	Citrus: for specific Florida counties <sup>c</sup> (low-pressure irrigation)	Maximum Single	0.50 to 1.50	1.5 to 4.5
Nemacur 3	3	Pineapple (band)	Maximum Single	3.0 to 8.0	9.0 to 24
Nemacur 3	3	Pineapple (band)	Maximum Seasonal	--	24
Nemacur 3	3	Pineapple (broadcast with soil incorporation) -- SLN Puerto Rico	Maximum Single	3.33 to 6.66	10 to 20
Nemacur 3	3	Pineapple (broadcast with soil incorporation) -- SLN Puerto Rico	Maximum Seasonal	--	20
Nemacur 3	3	Pineapple (foliar spray or drip irrigation)	Maximum Single	0.166 to 1.0	0.50 to 3.0
Nemacur 3	3	Pineapple (foliar spray or drip irrigation)	Maximum Seasonal	--	24
Nemacur 3	3	Pineapple & Ratoon Crop (foliar spray) -- Puerto Rico	Maximum Single	1.660 to 3.0	5.0 to 9.0
Nemacur 3	3	Pineapple & Ratoon Crop (foliar spray) -- Puerto Rico	Maximum Seasonal	--	10.0
Nemacur 3	3	Raspberry: except California (band)	Maximum Single <sup>d</sup>	1.0 to 2.0	3.0 to 6.0
Nemacur 3	3	Asparagus (band)	Maximum Single <sup>d</sup>	0.666	2.0

<sup>a</sup>Conversion equation for gallons of product/A to lbs a.i./A.

$$\frac{w \text{ (lbs a.i.)}}{1 \text{ (A)}} = \frac{x \text{ (gallons of product)}}{1 \text{ (A)}} \times \frac{y \text{ (lbs a.i.)}}{1 \text{ (gallon of product)}}$$

<sup>b</sup>Maximum seasonal application is not specified, assumed to be only once.

<sup>c</sup>Brevard, Broward, Charlotte, Citrus, Collier, Desoto, Glades, Hardee, Hendry, Hernando, Hillsborough, Indian River, Lee, Manatee, Marion, Martin, Okeechobee, Palm Beach, Pascoe, Pinellas, Putnam, St. Lucie, Sarasota, Seminole and Volusia.

<sup>d</sup>Maximum seasonal is the same as the maximum single application rate.



**Table B5. Conversion of Fluid Ounces/1,000 ft<sup>2</sup> to lbs a.i./A.**

Product	lbs a.i./ gallon	Use	Application Type	Product Rate Amount (fl oz/1,000 sq ft)	Product Rate Amount (lbs/A)	a.i. Rate Amount (lbs/A)
Nemacur 3	3.0	Turf	Maximum Seasonal	9.7	3.3	9.9
Nemacur 3	3.0	Turf	Maximum Single	--	--	20.0

<sup>a</sup>Conversion equation for fluid ounces (fl oz) of product/1000 ft<sup>2</sup> to lbs a.i./A.

$$z \frac{(\text{lbs a.i.})}{1 (\text{A})} = \frac{x (\text{fluid oz of product})}{1,000 (\text{ft}^2)} \times \frac{1 (\text{lb})}{128 (\text{fluid oz})} \times \frac{43,560 (\text{ft}^2)}{1 (\text{A})}$$

**Table B6. Conversion of lbs/1,000 linear feet (ft) of row to lbs a.i./A.**

Product	Fraction of a.i.	Use	Application Type	Row Spacing (in)	Single or Double Rows	Product Rate (lbs/1,000 ft of row)	Product Rate (lbs/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 10G	0.1	Iris, Lily and Narcissus bulbs	Maximum Single	42	Single	4.8 to 8.0	60 to 100	6.0 to 10.0
Nemacur 10G	0.1	Iris, Lily and Narcissus bulbs	Maximum Single	40	Single	4.8 to 8.0	63 to 104	6.3 to 10

<sup>a</sup>Conversion equation for lbs of product/1,000 linear ft of row to lbs a.i./A.

$$z \frac{(\text{lbs a.i.})}{1 (\text{A})} = \frac{x (\text{lbs of product})}{1 (1,000 \text{ linear ft of row})} \times j \frac{(1,000 \text{ linear ft crop rows})}{1 (\text{A})} \times \frac{i (\text{lbs a.i.})}{1 (\text{lb of product})}$$

where r is 1 for single rows and 2 for double rows planted within row spacing and j, the number of 1,000 linear ft rows planted per acre is:

$$j \frac{(1,000 \text{ linear ft of crop rows})}{1 (\text{A})} = \frac{43,560 (\text{ft}^2) / 1 (\text{A})}{\left( 1,000 (\text{row length in linear ft}) \times y (\text{row spacing in inches}) \times \frac{1 (\text{ft})}{12 (\text{inches})} \right)} \times r (\text{rows within row spacing})$$

**Table B7. Conversion of Fluid oz/1,000 linear ft of row to lbs a.i./A.**

Product	lbs a.i./ gallon	Use	Application Type	Row Spacing (in.)	Single or Double Rows	Product Rate (fl oz/1,000 ft of row)	Product Rate (lbs/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 3	3.0	Cotton	Maximum Single <sup>b</sup>	40	Single	2.4 to 3.3	0.25 to 0.34	0.74 to 1.0
Nemacur 3	3.0	Cotton	Maximum Single <sup>b</sup>	36	Single	2.4 to 3.3	0.27 to 0.37	0.82 to 1.1
Nemacur 3	3.0	Cotton	Maximum Single <sup>b</sup>	7	Single	2.4 to 3.3	1.40 to 1.93	4.2 to 5.8
Nemacur 3	3.0	Cotton (band or in-furrow)	Maximum Single <sup>b</sup>	40	Single	3.3 to 7.1	0.34 to 0.72	1.0 to 2.2
Nemacur 3	3.0	Cotton (band or in-furrow)	Maximum Single <sup>b</sup>	36	Single	3.3 to 7.1	0.37 to 0.81	1.1 to 2.4
Nemacur 3	3.0	Cotton (band or in-furrow)	Maximum Single <sup>b</sup>	7	Single	3.3 to 7.1	1.93 to 4.14	5.8 to 12
Nemacur 3	3.0	Cotton (soil injection)	Maximum Single <sup>b</sup>	40	Single	9.8	1.00	3.0
Nemacur 3 with Treflan 4EC	3.0	Cotton (band)	Maximum Single <sup>b</sup>	40	Single	3.9 to 8.9	0.40 to 0.91	1.2 to 2.7
Nemacur 3 with Treflan 4EC	3.0	Cotton (band)	Maximum Single <sup>b</sup>	36	Single	3.9 to 8.9	0.44 to 1.01	1.3 to 3.0
Nemacur 3 with Treflan 4EC	3.0	Cotton (band)	Maximum Single <sup>b</sup>	7	Single	3.9 to 8.9	2.28 to 5.19	6.8 to 16
Nemacur 3	3.0	Peanuts (band)	Maximum Single <sup>b</sup>	38	Single	4.5 to 7.3	0.48 to 0.78	1.5 to 2.4
Nemacur 3	3.0	Peanuts (band)	Maximum Single <sup>b</sup>	36	Single	4.5 to 7.3	0.51 to 0.83	1.5 to 2.5
Nemacur 3	3.0	Peanuts (band)	Maximum Single <sup>b</sup>	12	Single	4.5 to 7.3	1.53 to 2.48	4.6 to 7.5
Nemacur 3	3.0	Strawberries (band)	Maximum Single	48	Double	5.9 to 8.8	1.00 to 1.50	3.0 to 4.5
Nemacur 3	3.0	Strawberries (band)	Maximum Seasonal	48	Double	--	--	4.5
Nemacur 3	3.0	Eggplant (band at transplant)	Maximum Single <sup>b</sup>	36	Single	5.9	0.67	2.0
Nemacur 3	3.0	Table beets (band) in Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania	Maximum Single <sup>b</sup>	24	Single	4.0 to 6.0	0.68 to 1.02	2.0 to 3.1

<sup>a</sup>Conversion equation for fluid ounces (fl oz) of product/1000 linear ft of row to lbs a.i./A:

$$\frac{z \text{ (lbs a.i.)}}{1 \text{ (A)}} = \frac{x \text{ (fl oz of product)}}{1 \text{ (1,000 linear ft of row)}} \times \frac{1 \text{ (lb)}}{128 \text{ (fl oz)}} \times j \frac{(1,000 \text{ linear ft crop rows})}{1 \text{ (A)}} \times \frac{i \text{ (lbs a.i.)}}{1 \text{ (gallon of product)}}$$

where r is 1 for single rows and 2 for double rows planted within row spacing and j, the number of 1,000 linear ft rows planted per acre is:

$$j \frac{(1,000 \text{ linear ft of crop rows})}{1 \text{ (A)}} = \frac{43,560 \text{ (ft}^2\text{)}}{1 \text{ (A)}} \div \left( 1,000 \text{ (row length in linear ft)} \times y \text{ (row spacing in inches)} \times \frac{1 \text{ (ft)}}{12 \text{ (inches)}} \right) \times r \text{ (rows within row spacing)}$$

<sup>b</sup>Maximum seasonal application rate is not specified but it is assumed to be applied only once.

**Table B8. Conversion of Dry oz of Product/1,000 linear ft of row to lbs a.i./A.**

Product	Fraction of a.i.	Use	Application Type	Row Spacing (in.)	Single or Double Rows	Product Rate (oz/1,000 ft of row)	Product Rate (lbs/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 10G	0.1	Anthurium	Maximum Single <sup>b</sup>	42	Single	18.3 to 36.7	14.2 to 28.5	1.4 to 2.9
Nemacur 10G	0.1	Iris, Lily and Narcissus bulbs	Maximum Single <sup>b</sup>	40	Single	4.8 to 8.0	3.9 to 6.5	0.39 to 0.65
Nemacur 15G	0.15	Cotton	Maximum Single <sup>b</sup>	40	Single	6.0 to 8.0	4.9 to 6.5	0.74 to 1.0
Nemacur 15G	0.15	Cotton	Maximum Single <sup>b</sup>	36	Single	6.0 to 8.0	5.4 to 7.3	0.82 to 1.1
Nemacur 15G	0.15	Cotton	Maximum Single <sup>b</sup>	7	Single	6.0 to 8.0	28 to 37	4.2 to 5.6
Nemacur 15G	0.15	Cotton (band)	Maximum Single <sup>b</sup>	40	Single	8.0 to 12.0	6.5 to 9.8	1.0 to 1.5
Nemacur 15G	0.15	Cotton (band)	Maximum Single <sup>b</sup>	36	Single	8.0 to 12.0	7.3 to 10.9	1.1 to 1.6
Nemacur 15G	0.15	Cotton (band)	Maximum Single <sup>b</sup>	7	Single	8.0 to 12.0	37.3 to 56.0	5.6 to 8.4
Nemacur 15G	0.15	Peanuts (band)	Maximum Single <sup>b</sup>	72	Single	11.0 to 18.7	5.0 to 8.5	0.75 to 1.3
Nemacur 15G	0.15	Peanuts (band)	Maximum Single <sup>b</sup>	38	Single	11.0 to 18.7	9.5 to 16.1	1.4 to 2.4
Nemacur 15G	0.15	Peanuts (band)	Maximum Single <sup>b</sup>	36	Single	11.0 to 18.7	10.0 to 17.0	1.5 to 2.5
Nemacur 15G	0.15	Bok choy for California only	Maximum Single <sup>b</sup>	40	Double	14.7 to 18.4	24.0 to 30.1	3.6 to 4.5
Nemacur 15G	0.15	Cabbage and brussel sprouts (band)	Maximum Single <sup>b</sup>	40	Double	7.3 to 18.4	11.9 to 30.1	1.8 to 4.5
Nemacur 15G	0.15	Cabbage and brussel sprouts (band)	Maximum Single <sup>b</sup>	24	Single	7.3 to 18.4	9.9 to 25.0	1.5 to 3.8
Nemacur 15G	0.15	Eggplant (band)	Maximum Single <sup>b</sup>	72	Single	14.7	6.7	1.0
Nemacur 15G	0.15	Eggplant (band)	Maximum Single <sup>b</sup>	36	Single	14.7	13.3	2.0
Nemacur 15G	0.15	Garlic (in-furrow)	Maximum Single <sup>b</sup>	40	Double	9.2 to 18.4	15.0 to 30.1	2.3 to 4.5
Nemacur 15G	0.15	Okra except in California (band)	Maximum Single <sup>b</sup>	54	Single	14.7 to 18.4	8.9 to 11.1	1.3 to 1.7
Nemacur 15G	0.15	Okra except in California (band)	Maximum Single <sup>b</sup>	48	Single	14.7 to 18.4	10.0 to 12.5	1.5 to 1.9
Nemacur 15G	0.15	Okra except in California (band)	Maximum Single <sup>b</sup>	40	Single	14.7 to 18.4	12.0 to 15.0	1.8 to 2.3
Nemacur 15G	0.15	Okra except in California (band)	Maximum Single <sup>b</sup>	40	Double	14.7 to 18.4	24.0 to 30.1	3.6 to 4.5
Nemacur 15G	0.15	Non-bell peppers in California, Georgia, and Puerto Rico	Maximum Single <sup>b</sup>	96	Double	10.0 to 14.7	6.8 to 10.0	1.0 to 1.5
Nemacur 15G	0.15	Non-bell peppers in California, Georgia, and Puerto Rico	Maximum Single <sup>b</sup>	72	Double	10.0 to 14.7	9.1 to 13.3	1.4 to 2.0
Nemacur 15G	0.15	Strawberries (band)	Maximum Single	48	Double	14.7 to 22.0	20.0 to 29.9	3.0 to 4.5

**Table B8. Conversion of Dry oz of Product/1,000 linear ft of row to lbs a.i./A.**

Product	Fraction of a.i.	Use	Application Type	Row Spacing (in.)	Single or Double Rows	Product Rate (oz/1,000 ft of row)	Product Rate (lbs/A)	a.i. Rate (lbs/A) <sup>a</sup>
Nemacur 15G	0.15	Non-bearing strawberry nursery stock (band)	Maximum Single	48	Double	17.0	23.1	3.5
Nemacur 15G	0.15	Non-bearing strawberry nursery stock (band)	Maximum Seasonal	48	Double	--	--	7.0

<sup>a</sup>Conversion equation for dry ounces (oz) of product/1000 linear ft of row to lbs a.i./A.

$$z \frac{(\text{lbs a.i.})}{1 (\text{A})} = \frac{x (\text{dry oz of product})}{1 (1,000 \text{ linear ft of row})} \times \frac{1 (\text{lb})}{16 (\text{dry oz})} \times j \frac{(1,000 \text{ linear ft of crop rows})}{1 (\text{A})} \times \frac{i (\text{lbs a.i.})}{1 (\text{lb of product})}$$

where r is 1 for single rows and 2 for double rows planted within row spacing and j, the number of 1,000 linear ft rows planted per acre is:

$$j \frac{(1,000 \text{ linear ft of crop rows})}{1 (\text{A})} = \frac{43,560 (\text{ft}^2) / 1 (\text{A})}{\left( 1,000 (\text{row length in linear ft}) \times y (\text{row spacing in inches}) \times \frac{1 (\text{ft})}{12 (\text{inches})} \right)} \times r (\text{rows within row spacing})$$

<sup>b</sup>Not specified on label but assumed applied only once.

## APPENDIX C: Summary of Simulated and Actual Field Exposure Studies

**Nemacur 3 Simulated Field Study, Bare Soil.** Fenamiphos was applied to bare soil at the rate of 6, 10, and 20 lb a.i./A and immediately incorporated to a depth of 2 to 3 inches. Under the conditions of the study, Nemacur 3 had no significant effect on mortality, weight gain, clinical signs, gross lesions or brain cholinesterase activity on the test species, Northern Bobwhite Quail. All study mortalities were limited to day 1. No further signs of intoxication were observed. The study was found to be scientifically sound but did not meet current guideline requirements (MRID 121291).

**Nemacur 3 Actual Field Study, Orchard.** Twenty-six acres of orchard (apple and cherry) were sprayed at the rate of 23.8 lb a.i./A in the late spring of 1982. Under these conditions, Nemacur 3 was associated with significant avian (robins, sparrows and starlings) and mammalian (rabbits and woodchucks) mortalities over the next five days. Then it rained; the hazard to nontarget wildlife was apparently eliminated by 0.9 inches of rainfall. Repopulation of the treated orchard was nearly complete by one-month post-application. The study was found to be scientifically sound but did not meet current guideline requirements (MRID 121290 and 121293).

**Nemacur 10G Actual Field Study, Turf Use on Golf Course Sites.** In a bird census study, several instances of mortality and/or behavioral deficits were observed after Nemacur 10G was applied according to label directions on golf courses. In addition, some birds showed symptoms of behavioral impairment.

Prior to application to the golf courses, birds at the golf courses were caught using 15 to 30 foot mist nets. All captured birds were marked with a colored, plastic leg-band and palatial tags. Mist nets were set up each day at daybreak and removed prior to dark. Only birds with small territories, such as Mocking Birds, Brown Thrashers, Common Ground Doves and Cardinals, were tagged. The rationale of the study's cooperators was that only birds with small territories would most likely be exposed to fenamiphos, and captured migratory birds and/or wide-ranging species would move offsite and be impossible to recapture. However, according to the report, golf course personnel, find most often the carcasses of Cattle Egrets, which would not be included in the study design, and various grackles after Nemacur 10G application.

Observations of deficit behavior and the number of dead birds found over a 2.5 day period post-treatment were recorded and are presented in Table C1; however, birds taking flight and moving offsite after feeding were not monitored. Therefore, the number of intoxicated and dead birds is potentially much higher than that observed. Flocking birds such as most blackbirds, and/or birds that roost such as Mourning Doves may also utilize habitat that is well away from the treatment area after visiting the site. Unless these areas are thoroughly searched, the impact to certain species may go unnoticed. Additionally due to scavenging of the carcasses by other species, intensive observations should occur within the first 48 hours after application. Observations of birds feeding on treated fairways or adjacent water were compiled from 6 golf courses, at 9 fairways and represent only 31.5 observation hours occurring over a 2.5 day period. Therefore, the magnitude and significance of adverse effects to native bird populations resulting from an application of Nemacur 10G to turf cannot be totally assessed given the limitations of this study (MRID 41012902).

Of the species listed in Table C1, Common and Boat-tailed Grackles, Northern Mockingbirds and European Starlings were observed consuming mole crickets on the fairways. Nemacur residues in dead or dying mole crickets on the day of application averaged 96.27 ppm in those sampled. Of the 158 birds observed, 14 displayed signs of intoxication such as limping, salivating and loss of balance, and 13 were found dead after exposure to Nemacur 10G.

**Table C1. Observed Bird Deficit Behavior and Death After Nemacur 10G Application to Selected Golf Course Sites**

Bird Species	Number Observed Feeding	Number Observed with Deficit Behavior	Number of Deaths
Fish Crow, <i>Corvus ossifragus</i>	39	5	2
European Starling, <i>Sturnus vulgaris</i>	26	1	0
Northern Mockingbird, <i>Mimus polyglottos</i>	26	2	5
Boat-tailed Grackle, <i>Quiscalus mexicanus</i>	20	2	2
Common Grackle, <i>Quiscalus quiscula</i>	11	0	0
Blue Jay, <i>Cyanocitta cristata</i>	12	3	1
Ground Dove, <i>Columbina passerina</i>	4	0	0
Northern Cardinal, <i>Cardinalis cardinalis</i>	4	0	0
Brown Thrasher, <i>Toxostoma rufum</i>	4	1	1
Great Horned Owl, <i>Bubo virginianus</i>	2	0	0
Common Bobwhite Quail, <i>Colinus virginianus</i>	2	0	0
Red-Winged Blackbird, <i>Agelaius phoeniceus</i>	2	0	0
Red-Bellied Woodpecker, <i>Melanerpes carolinus</i>	1	0	0
Killdeer, <i>Charadrius vociferus</i>	1	0	0
Great Crested Flycatcher, <i>Myiarchus crinitus</i>	1	0	0
Osprey, <i>Pandion haliaetus</i>	1	0	0
Great Blue Heron, <i>Ardea herodias</i>	1	0	0
Downy Woodpecker, <i>Picoides pubescens</i>	1	0	0
Loggerhead Shrike, <i>Lanius ludovicianus</i>	0	0	2
Totals	158	14	13

**Nemacur 3 Actual Field Study, Tobacco Field.** The terrestrial field study was submitted to evaluate the effects of Nemacur 3 on birds and other wildlife under actual field conditions. The study occurred over a two-year period on tobacco field plots in Pitt and Greene Counties of North Carolina, a major tobacco growing region of the U.S.. Fenamiphos, formulated as Nemacur 3, was applied at 6 lb a.i./A to each of the three treated fields using ground sprayers followed by soil incorporation.

A total of 114 species of birds were observed in the study area. Thirty-five of these species were observed foraging in or over the test fields during or immediately following application. Some of the species observed were killdeer (*Charadrius vociferus*), Ring-billed Gulls (*Larus delawarensis*), Fish Crows (*Corvus ossifragus*) and American Crows (*Corvus brachyrhynchos*), Horned Larks (*Eremophila alpestris*), American Robins (*Turdus migratorius*), European Starlings (*Sturnus vulgaris*), Northern Cardinals (*Cardinalis cardinalis*), and White-throated Sparrows (*Zonotrichia albicollis*). All of the aforementioned species are known to eat insects, seeds and berries, but Killdeer and Ring-billed Gulls are also known to consume small marine life and carrion (dead animals); therefore, fenamiphos induced primary poisoning may also lead to secondary poisonings.

In the first year of the study, bird, mammal, reptile and amphibian carcasses were found at study sites after fenamiphos application. The dead birds found were all domestic poultry located solely in the treatment



areas. Of six dead mammals found, three were in the control and three were in the treatment areas. Two dead reptiles and four dead amphibians, all in the treatment areas, were also found.

In the second year of the study, a total of 73 vertebrate mortalities were documented. Of these, 22 carcasses were found on treated plots, and 27 carcasses were found on control plots prior to application. After application of Nemacur 3 to the tobacco field, 12 carcasses were found on treatment plots and 12 were found on control plots. Although the number of casualties on treatment plots was not greater than the number on control plots, Nemacur 3 cannot be ruled out as the possible cause of death. Exposed vertebrates could have migrated from the treatment plots to control plots prior to death, and it was not reported whether tissue sample analyses were conducted on the carcasses that were found. But Nemacur residues were detected in all matrices sampled: soil (0.13 to 12.88 ppm in top one-tenth inch), water (0.07 to 2.02 ppm), and invertebrate carcasses (0.10 to 0.12 ppm).

This study demonstrates that a high survival pressure already exists on various terrestrial vertebrates which utilize agricultural areas for food or shelter. However, due to the manner in which the study was conducted, one cannot determine whether incorporating Nemacur 3 directly after applying it at a rate of 6 lb a.i./A will reduce or eliminate fenamiphos exposure and resultant adverse effects to wildlife (MRID 42029903).

**Nemacur 15G Actual Field Study, Florida Citrus Grove.** The application of Nemacur 15G to Florida citrus groves resulted in depressed plasma cholinesterase levels in nearly one third of the avian local species for approximately 30 days post-treatment (MRID 42029901 and 42029902). Cholinesterase levels were lowest between 7-to-10 days post-application.

Birds were caught using 15-to-30 foot mist nets. All captured birds were marked with a colored, plastic leg-band and palatial tags. Mist nets were set up each day at daybreak and removed prior to dark. Only birds with small territories, such as mocking birds, brown thrashers, common ground doves and cardinals, were tagged. The rationale of the study's cooperators was that only birds with small territories would most likely be exposed to fenamiphos, and captured migratory birds and or wide-ranging species would move offsite and be impossible to recapture. Of those recaptured and tested, cholinesterase levels returned to normal 30 days after initial application. The Nemacur mean residue level on soil and vegetation samples taken directly after application were 29.41 and 0.72 ppm, respectively. The mean residue on/in invertebrate species collected the day after application was 15.89 ppm.

A bird and mammal census characterization report submitted by the registrant contained the following information about each study site: surrounding wildlife and aquatic habitats, species use and abundance of these citrus groves, soil-type descriptions, pest management history, and nearest weather recording stations. The census report documented bird and mammal abundance in the middle of the grove, at the edge of the grove, and at the edge of the surrounding wildlife habitat. In the middle of the grove, 26 different bird species numbering from 136 to 1,000 birds per 100 acres was recorded. At the grove's perimeter, 27 different bird species numbering from 56 to 265 birds per 100 acres was recorded. In the surrounding wildlife habitat, 47 different bird species numbering from 113 to 354 birds per 100 acres was recorded. The mammalian species sighted were the Eastern Cottontail Rabbit (*Sylvilagus floridanus*), Raccoon (*Procyon lotor*), Opossum (*Didelphis marsupialis*), Armadillo (*Dasypus novemcinctus*), Eastern Gray Squirrel (*Sciurus carolinensis*), River Otter (*Lutra canadensis*), Wild Boar (*Sus scrofa*), and Bobcat (*Lynx rufus*).

Scavenger rates were also recorded and were very high. Over 75% of the dead birds recorded through searches were scavenged by other birds, fire ants, and mammals within 12 hours of pesticide exposure, and all were scavenged within 2.5 days. EFED staff visited this field site and were informed that carcass searches were conducted at each site; however, on some days searches were conducted by one individual searching alone for 6 hours over these large acreages. Hence the number of birds killed from fenamiphos exposure is potentially much higher, but carcasses were simply not found due to inadequate monitoring and high scavenging rates.

Regarding this specific study, the number of treated sites was too few to determine whether an "effect" or "no effect" occurred using the binomial theorem (Fite et al., 1988), and true carcass searches were not conducted. Due to the study limitations, it can not be used to assess the magnitude and significance of the adverse effects from an application of Nemacur 15G at a rate of 20 lb a.i./A to native bird populations living in and around citrus groves. Yet, this field study did confirm that adverse effects to nontarget birds living in and around citrus groves can be expected from a single application of Nemacur 15G. In addition to increased acute mortality, the local bird population (and other exposed terrestrial vertebrates) will be negatively affected by depressed blood cholinesterase levels for up to 30 days post-treatment. Debilitated birds (and other terrestrial vertebrates) are more susceptible to predation and will have less chance of survival due to fenamiphos exposure.

**Nemacur 3 Simulated Field Study, Pineapple Field.** Ring-necked Pheasants (*Phasianus colchicus*) and Rice Birds (*Lonchura punctulata*) were exposed to a pineapple field sprayed with Nemacur 3. The birds were held in cages positioned over a treated area to give 0, 50 and 100% exposure for a 14-day period. Approximately 25% mortality occurred among Rice Birds in the 100% exposure area. At 50% exposure, Rice Birds experienced no behavioral differences, toxic symptoms or deaths. At 50 and 100% exposure, Ring-neck Pheasants demonstrated no behavioral differences, toxic symptoms or deaths.

The application rate was 5 lb of fenamiphos in 250 gallons of water per acre. The test birds were provided 327 ft<sup>2</sup> of pen area in the treated field one hour after application. The 327 ft<sup>2</sup> area received 47.3 ml of the formulation or 17 grams of the a.i. in 1.9 gallons of water by means of a hand spray boom. The amount of fenamiphos in the pen area equated to 52 mg a.i./ft<sup>2</sup>.

Several major problems with the test design of this study affect the reliability of its results. The study should have measured the magnitude of adverse affects to wild birds after foraging on resident food items in a fenamiphos treated field. However, test birds were supplementally fed cracked corn, their typical diet. In addition, the number of test birds and dosing levels were too few, the pens were not moved daily, and carcasses of Rice Birds were not necropsied to determine cause of death (ACC 120301).

**Nemacur 15G Simulated Field Study, Pineapple Field.** Ring-necked Pheasants and Rice Birds were exposed to a pineapple field treated with Nemacur 15G. The birds were held in cages positioned over a treated area to give 0, 50 and 100% exposure for a 14-day period. Approximately 10% of the rice birds and 20% of the Ring-necked Pheasants died at 100% exposure. At 50% exposure, Rice Birds experienced no behavioral differences, toxic symptoms or deaths. At 50 and 100% exposure, ring-neck pheasants demonstrated no behavioral differences, toxic symptoms or deaths. The application rate was 40 lb of fenamiphos per acre. The test birds were penned in eight cages whose base dimensions when collectively added would comprise a total of 200 ft<sup>2</sup> of exposure area. These cages were then placed on a 327 ft<sup>2</sup> surface of treated field one hour after application. The amount of fenamiphos in the exposure area equated to 416 mg a.i./ft<sup>2</sup> when unincorporated. The Nemacur 15G was incorporated 4-to-6 inches with a tractor-mounted roto-tiller. In addition, the field study discusses laying a 24-inch plastic mulch strip, covering

the edges with soil and planting the pineapple through the plastic. Therefore, the granular material potentially could have been fully unavailable to the test birds.

In summary, several major problems with the test design of this study affect the reliability of its results. Test birds were supplementally fed cracked corn, their typical diet; therefore, test birds could successfully feed and potentially never be exposed to the toxicant. In addition, the number of test birds and dosing levels were too few, the pens were not moved daily, and carcasses of rice birds and ring-necked pheasant were not necrosied to determine cause of death. It was also unclear as to how much of the soil remain uncovered by plastic mulch, making it difficult to determine whether exposure to the toxicant occurred (ACC 120301).

**Nemacur 15G Simulated Field Study, Irrigated and Non-irrigated Fields.** Nemacur 15G was applied at the rate of 20 lb a.i./A. The residue in ppm would be approximately 441 ppm before watering in. The control plot and the two treated plots were each 660 ft<sup>2</sup>. Each treated plot received an application followed by wetting the area with 0.5 inches of water.

Several major problems with the test design of this study affect the reliability of its results. Cages were placed in the treated areas after the initial application and were never moved again throughout the study.

The test birds' diets were supplemented on a daily basis thereby reducing their consumption of field resident food items, and as a consequence, fenamiphos exposure. Notwithstanding, English Sparrows suffered higher mortality in treated areas where Nemacur 15G was not watered in, than in the control or the treated and irrigated areas. In the non-irrigated pens, where feed was withheld for 8 hours, mortality was highest. The mortality in all pens decreased as the study progressed, and with the occurrence of two rain events, the incidence of mortality appeared to decline. In the bobwhite quail pens, two birds died in the treated, non-irrigated area. All birds, however, lost weight during the study with birds in the treated, irrigated areas averaging a weight loss of 4 grams; birds in the treated, non-irrigated areas averaging a weight loss of 14 grams; and birds in the control averaging a weight loss of 8 grams. No deaths occurred in the test population of rabbits. Weight gain was greatest in the control group; weight gain was average in the group penned in the treated, irrigated area; and weight gain was least in the group penned in the treated, non-irrigated area (ACC 120301).

**Nemacur 3, An Evaluation of its Effects Upon Avian Species in and Around Citrus Groves on the Central Florida Ridge.** To support reregistration, this study was conducted to determine the magnitude of exposure and acute hazard primarily to birds, but also to other terrestrial wildlife, caused by applications of Nemacur 3 to citrus groves in Florida's Central Ridge using chemigation—a use that EPA had determined would likely result in adverse effects to nontarget terrestrial wildlife. The specific objectives were to (1) document the number and kinds of birds exposed to Nemacur 3 and the magnitude and duration of this exposure, (2) document the numbers and kinds of birds dying as a result of exposure to Nemacur 3, (3) estimate the impact of Nemacur 3 applications on the survival of selected resident species, and (4) determine environmental concentrations of fenamiphos in soil and ground-dwelling invertebrates.

The author's designed the field study to try and ensure that there was at least an 80% probability that a 20% reduction in avian survival, if caused by fenamiphos application to the citrus grove, would be detected. The authors mistakenly conclude, "This implies that a pesticide-induced decrease in survival of 20% or more is unacceptable, whereas a smaller impact may be acceptable." The particular guidance the authors are citing was EPA's *Guidance Document for Conducting Terrestrial Field Studies*. However, on page 7 of EPA's guidance document, these percentages are provided only as an *example* on how to

calculate the number of sites that would be needed using the binomial theorem. These values do not reflect any EPA acceptable levels of avian mortality.

Wildlife observed consisted of 69 avian, 12 mammalian, 6 reptilian, and 4 amphibian species in the overall study area of which 54 avian, 12 mammalian, 4 reptilian, and 2 amphibian species were observed in the citrus groves. Totals of 1,165 and 1,835 avian captures occurred on treated and control replicates, respectively. More birds were captured on control than treated replicates at pre- and post-application; however, the difference in the mean number of captures per session was not significant ( $t=2.28$ ,  $p > 0.05$ ). Eighty-five vertebrate mortalities were found during the field portion of the study. Of these 33 (39%) were found on treated replicates (mean = 5.5/replicate, consisting of means of 3.0 birds, 1.3 mammals, one reptile and 0.17 amphibian) and 52 (61%) were found on control replicates (mean = 8.7/replicate, consisting of means of 4.8 birds, 2.5 mammals, 1.0 reptile and 0.33 amphibian). Twenty-four of the mortalities found on treated replicates were found after application, while 33 mortalities were found during an equivalent time period on the control replicates. Birds which died or were injured during the trapping process were not included in the statistically considered data. Forty-six mortalities were considered attributable to trapping. Forty-one were analyzed for Nemacur 3 residues in the GI tract and liver. The report indicates that only two individuals had detectable residues of Nemacur 3.

Blood cholinesterase levels were monitored in ten focal species, species determined to be at potentially high risk. Nine of the selected focal species (Mourning Dove, Common Ground Dove, Northern Cardinal, Rufous-sided Towhee, Brown Thrasher, Northern Mockingbird, Northern Bobwhite, Blue Jay and Red-winged Blackbird) were considered to be predominantly ground foragers and thus likely be exposed to the microjet ground applications of Nemacur 3, and one species, White-eyed Vireo, was selected as a control because it is a canopy forager, presumably less likely to be exposed to Nemacur 3 residues. These focal species comprised 72.6% of all captures. A total of 1,936 blood samples were collected from ten focal species during the study: 796 from birds on treated replicates (mean = 132.7 samples/replicate) and 1,140 from birds on control replicates (mean = 190 samples/replicate). There was no significant difference between the number of focal species captured between pre- and post-application periods either on treated replicates ( $t=1.12$ ,  $p > 0.05$ ) or on control replicates ( $t=0.86$ ,  $p > 0.05$ ).

The authors concluded the following:

1. The proportion of birds sampled after application of Nemacur 3 having blood cholinesterase less than or equal to the diagnostic threshold was 16% for treated replicates and 2.7% for control replicates; hence, the report suggests that approximately 13% of the birds at treated sites were exposed to a significant dose of the test substance; and
2. An avian survival index for each replicate was calculated based on the proportion of birds with blood cholinesterase levels above the diagnostic threshold (mean survival pre- and post application indices were 0.98 and 0.85 on treated replicates, and 0.96 and 0.97 on control replicates.
3. Therefore, based on these results, the authors concluded that the null hypothesis--treatment with Nemacur 3 results in an avian survival index less than or equal to 80% of the control ( $t=2.65$ ,  $df=5$ ,  $p < 0.05$ )--was rejected.

The study does demonstrate that birds exposed to low-volume microjet ground applications of Nemacur 3 have significantly depressed brain cholinesterase activity; however, the reviewer does not agree with the underlying assumptions regarding setting the "diagnostic threshold of significant exposure" at 50% of the pre-exposure levels for acute mortality. The study authors defined the "diagnostic threshold of significant



exposure” as one-half the overall mean blood cholinesterase value for each control and pre-application individual of that species and that only birds with blood cholinesterase levels above the diagnostic threshold are assumed to survive. This presumes that cholinesterase inhibition at less than 50% is “not a significant exposure” and does not affect the exposed individual’s ability to survive; however, many sublethal impacts to birds from organophosphate applications have been documented in recent years which cause bird population declines. Sublethal doses of organophosphate pesticides have been documented to affect learning ability and altered reproductive capability of bobwhite quail, at doses well below those causing outward signs of toxicity. Altered reproductive capability was characterized by impaired development of ovarian follicles, cessation of egg production, and reduced blood levels of reproductive hormones.<sup>39</sup> Research conducted on another organophosphate pesticide, methyl parathion (MeP), concluded that Northern Bobwhites that received 6 mg/kg of MeP had a lower survival rate than control birds. Laboratory studies have indicated that administration of 6 mg/kg MeP to pen-reared bobwhite would result in approximately 40% depression of brain cholinesterase 4 hours post-treatment. The decreased survivability was primarily due to increased avian predation, possibly resulting from subtle behavioral impairments rather than the overt toxic effects of the organophosphate chemical.<sup>40</sup> Long-term disruption of bird feeding and breeding due to conditioned taste aversion to food items tainted with an organophosphate pesticide also will contribute to a reduction in avian diversity.<sup>41</sup>

In addition, the reviewer does not agree with the inclusion of Groups 1 and 7 in the statistical analyses, when the control sites of these areas received applications of other cholinesterase inhibiting chemicals, or inclusion of the White-eyed Vireo as a control. Based on the submitted spraying regime for the test groves the individuals in Control groups 1 and 7, were exposed to other cholinesterase inhibiting insecticides. The White-eyed Vireo data (Appendix XIV, Capture Record for Focal Species and ChE Values) indicate depressed blood cholinesterase levels in some individuals such that they should not serve as a focal species control. These data and their associated treatment replicates should be removed from consideration in the analyses as inclusion may artificially lower the “diagnostic threshold of significant exposure”.

One can conclude that birds (and other terrestrial vertebrates) exposed to single or sequential low-volume microjet ground applications of Nemacur 3 at citrus use sites will result in impairment, acute mortality, and population reductions at levels which are statistically significant, but the magnitude and extent of the acute risks to birds (and other terrestrial vertebrates) cannot be quantified from the results of this study. Additional uncertainties are the differences in interspecies sensitivity and what role these differences play in population changes. Reoccurring bird mortalities and population reductions, which will occur from

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<sup>39</sup> Fleming, W. James, “Summaries of Selected Studies on Wildlife Pollution, Progress Reports from the Patuxent Wildlife Research Center for the Year 1981,” U.S. Department of Interior, Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland 20708.

<sup>40</sup> Buerger, Theodore T., Ronald J. Kendall, Brad S. Mueller, Theodore DeVos, and Bill A. Williams, “Effects of Methyl Parathion on Northern Bobwhite Survivability,” *Environmental Toxicology and Chemistry*, Volume 10, pp. 527-532, 1991.

<sup>41</sup> Nicolaus, Lowell K. and Hansoo Lee, “The First Evidence of Long-Term Changes in Bird Behavior Produced by Low Acute Exposure to Organophosphate,” 1998, Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois 60115.

applications of Nemacur 3 to citrus use sites, have been defined by the Avian Effects Dialogue Group as impacts of concern<sup>42</sup> (MRID 437379-01).

**Nemacur 10G , An Evaluation of the Effects Upon Birds at Golf Courses in Florida.** To support reregistration this study was conducted to evaluate the effects of Nemacur 10G on birds when it is applied to golf course turf at the highest labeled application rate of 10 lbs a.i./A. The study was designed to ensure that at least an 80% probability that a 20% reduction in avian survival, if caused by fenamiphos application to the golf course, would be detected. The particular guidance the authors cited for the design was EPA's *Guidance Document for Conducting Terrestrial Field Studies*. Six golf courses were included in the study design and consisted of Capital City, Seminole, Killearn, Mountain Lake, Lake Region, and Grenelefe in Florida.

Use of the treated turf areas by birds was monitored during two one-hour periods the day of application and during a one-hour period the morning after application. The report states that all golf courses were very similar in species diversity between control and treatment plots. The total number of species observed for the six golf courses was (control/treatment) Capital City-60/55, Seminole-45/51, Killearn-46/51, Mountain Lake-57/62, Lake Region-57/67, and Grenelefe-49/53. The Blue Jay was the most abundant focal species, with an average relative abundance of 16% (range 7.6 - 30.1%) for control and treatment plots. The Northern Mockingbird and Cardinal (focal birds) were also among the most relatively abundant species. The most common nonfocal species observed in fairways were the European Starling, Common Grackle, and the Boat-tailed Grackler. Population estimates for all focal species combined ranged from 135-to-1,021 birds for control plots and 114-to-728 birds for treated plots. The Blue Jay had the greatest average population, with a mean population of 95 birds (range 44-to-246) on control plots and 77 (range 32-to-162) on treated plots. Visual censuses indicated an average of 38% (range 14-to-54%) of the individuals of the focal species were marked. Population estimates for all focal species combined ranged from 114-to-1,021 birds per plot.

The report stated that the first 48 hours post-application is the period considered to be of greatest risk to the focal population. To determine the survival index, birds resighted either Day 3 or Day 1 were considered to be part of the population at risk. Of these individuals, those which were resighted on or after day 3 post-application were considered "survivors." The proportion surviving on control and treatment plots were compared using a standard one-sided t-test on the mean difference of these pairs. The number of birds sighted foraging on treated turf during or immediately following application ranged from 5 at Grenelefe to 112 at Killearn golf course. The most frequently observed focal species in the fairway was the Northern Mockingbird. Two birds were found dead (1 European Starling and 1 Loggerhead Shrike) during the exposure monitoring periods after application. The starling was first noticed immobile in the rough next to a fairway and later died. Seven other birds (2 American Robins, 2 Blue Jays, 1 Brown-headed Cowbird, 1 Fish Crow, and 1 Orchard Oriole) were observed with symptoms of toxicity during the exposure monitoring periods. The symptoms noted were ataxia, immobility, salivation, and convulsions. These birds all recovered. All birds showing symptoms, except the 2 Robins, were noted during the day of application. The two robins were observed with symptoms the morning after application. In addition, the report indicates that carcasses of unidentified mammals, reptiles and amphibians were also found on Day 0, 1,2,3, 5, and 7 post-application.

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Assessing Pesticide Impacts on Birds: Final Report of the Avian Effects Dialogue Group, 1988-1993, Resolve Inc. 1994, 1250 24<sup>th</sup> Street NW /Suite 500, Washington, D.C. 20037.



The authors concluded that there was no evidence that pesticide treatment increased bird mortality, that average bird survival rates were essentially equal at control and treatment sites and that in fact, more carcasses were found at control sites than at treatment sites. However as pointed out for other studies the limited amount of time spent observing birds and the manner in which carcasses were searched for likely resulted in underestimation of mortality. In addition the focal population may have been significantly impacted by the marking procedure such that effects are underestimated, there was a significant drop in the number of alive birds in the focal population when compared to the number of marked birds, in some instances almost 50% (Tables 9 and 10 of the report). Additionally declines in individual focal species from pre-application to Day 3, both in the controls and treatment levels, of approximately 10-to-30% were recorded, one can conclude that adverse impacts are occurring at statistically significant levels but one cannot conclude from the study however the causal factor. The study attempted to evaluate population effects on one endpoint alone, acute mortality. Because this study was conducted during the breeding period, nest monitoring would have been useful to evaluate the effect of NemaCur 10G on breeding birds. Additionally, blood cholinesterase levels were not monitored such that exposure to the resident populations are unknown.

## APPENDIX D: Ecological Incidents Summary

**Ecological Incidents.** The number of documented kills in the Ecological Incident Information System is believed to be but a very small fraction of total mortality caused by pesticides. Mortality incidents must be seen, reported, investigated, and have investigation reports submitted to EPA to have the potential to get entered into a data base. Incidents often are not seen, due to scavenger removal of carcasses, decay in a field, or simply because carcasses may be hard to see on many sites and/or few people are systematically looking. Poisoned birds may also move off-site to less conspicuous areas before dying. Incidents seen may not get reported to appropriate authorities capable of investigating the incident because the finder may not know of the importance of reporting incidents, may not know who to call, may not feel they have the time or desire to call, may hesitate to call because of their own involvement in the kill, or the call may be long-distance and discourage callers. Incidents reported may not get investigated if resources are limited or may not get investigated thoroughly, with residue and cholinesterase (ChE) analyses, for example. Also, if kills are not reported and investigated promptly, there will be little chance of documenting the cause, since tissues and residues may deteriorate quickly. Reports of investigated incidents often do not get submitted to EPA, since reporting by states is voluntary and some investigators may believe that they don't have the resources to submit incident reports to EPA.

Incidents reports submitted to EPA since approximately 1994 have been tracked by assignment of I-#s in an Incident Data System (IDS), microfiched, and then entered to a second database, the Ecological Incident Information System (EIIS). This second data base has some 85 fields for potential data entry. An effort has also been made to enter information to EIIS on incident reports received prior to establishment of current data bases. Although many of these have been added, the system is not yet a complete listing of all incident reports received by EPA. Incident reports are not received in a consistent format (e.g., states and various labs usually have their own formats), may involve multiple incidents involving multiple chemicals in one report, and may report on only part of a given incident investigation (e.g., residues). While some progress has been made in recent years, both in getting incident reports submitted and entered, there has never been the level of resources assigned to incidents that there has been to the tracking and review of laboratory toxicity studies, for example. This adds to the reasons cited above for why EPA believes the documented kills are but a fraction of total mortality caused by fenamiphos and other highly toxic pesticides.

Incidents have continued to occur on remaining use sites, especially lawn and other turf sites. Waterfowl are especially attracted to sites that have water bodies nearby. Non-waterfowl can be attracted to nearly any vegetated site (and many nonvegetated sites), although those with food, shelter, and/or water can be the most attractive.

Incidents have occurred with both liquid and granular formulations of fenamiphos. Incidents have occurred despite watering in (irrigation) on turf, possibly due to residues still on the turf blades or in the thatch, or due to puddling (water can attract birds). Birds can receive a lethal dose quite quickly, as was shown in a golf course where wigeon were killed on treated turf in just 30-40 minutes of feeding. Fenamiphos is toxic enough to birds that most reductions of application rates are not likely to prevent mortality. Incidents entered into EIIS are categorized into one of several certainty levels: highly probable, probable, possible, unlikely, or unrelated. In brief, "highly probable" incidents usually require carcass residues, substantial ChE inhibition (for chemicals such as fenamiphos and other organophosphates that depress brain and blood cholinesterase), and/or clear circumstances regarding the exposure. "Probable" incidents include those where residues were not available and/or circumstances were less clear than for

“highly probable.” “Possible” incidents include those where multiple chemicals may have been involved and it is not clear what the contribution was of a given chemical. The “unlikely” category is used, for example, where a given chemical is practically nontoxic to the category of organism killed and/or the chemical was tested for but not detected in samples. “Unrelated” incidents are those that have been confirmed to be not pesticide-related.

**Table D1: Incident Data and Ecological Incident Information Systems Summary Reports as of 08/10/2001.**

Date	State	County/City	Common Name/ Organism Class	Total Affected	Tissue Analyses (Y/N)	Formulation Type/ Method Application	Use/Misuse	Certainty Index
11/10/2000	CA	Sonoma	Birds (mainly robins and bluebirds)	320	Yes	Fenamiphos/NR	Grape vineyard	Highly Probable
07/01/00	CA	Mendocino	Birds	17	Yes	Fenamiphos/NR	Grape vineyard-puddling of water	Highly Probable
02/02/98	CA	Fresno	Fish	1,000	No	Fenamiphos/NR	Kiwi fruit Orchard/Accidental Misuse	Highly Probable
			Birds	28				
11/04/96	FL	Bay	Birds (waterfowl)	28	No	Fenamiphos/NR	Golf Course/Registered Use	Highly Probable
06/12/96	FL	Orange	Tilapia Fish	NR	No	Fenamiphos/NR	Golf Course Greens/NR	Unlikely
02/02/96	NR	NR	Fish	200	No	Fenamiphos/NR	Building/Accidental Misuse	Highly Probable
06/09/95	FL	Palm Beach	Birds	NR	No	Fenamiphos/NR	Golf Course/ Accidental Misuse	Probable
05/27/95	FL	Broward	Fish	NR	No	Nemacur 3	Golf Course/Registered Use	Probable
07/08/94	FL	Miami	Fish	NR	No	Nemacur 10G	Golf Course/Some Misuse Regarding Improper Use of Protective Equipment	Unknown
			Birds	NR				
05/26/94	FL	Hollywood	Fish	NR	No	Nemacur 10G	Golf Course/Registered Use	Unknown
			Birds	NR				
07/13/93	FL	Dade	Fish	>200	Yes	NR	Golf Course/Registered Use	Highly Probable
07/08/93	FL	Dade	Fish	200-1,000	Yes	Nemacur 10G at 10 lbs a.i./A /Broadcast with soil incorporation	Golf Course/Registered Use	Highly Probable
			Birds	NR				
07/07/93	FL	Dade	Fish	200-1,000	Yes	Nemacur 10G /Broadcast no soil Incorporation	Golf Course/Registered Use	Highly Probable
07/06/93	FL	Dade	Fish	200-1,000	Yes	Nemacur 10G/Broadcast with soil incorporation	Golf Course/Registered Use	Highly Probable
06/11/92	LA	Orleans	Fish	NR	No	Fenamiphos/NR	Golf Course/ Registered Use	Probable
07/29/91	FL	Hobe Sound	Fish	NR	No	Nemacur 10G	Golf Course/Registered Use	Unknown
			Birds	NR				
	FL	Lakeland	Fish	NR	No	Nemacur 10G	Golf Course/Registered Use	Unknown

**Table D1: Incident Data and Ecological Incident Information Systems Summary Reports as of 08/10/2001.**

Date	State	County/City	Common Name/ Organism Class	Total Affected	Tissue Analyses (Y/N)	Formulation Type/ Method Application	Use/Misuse	Certainty Index
			Birds	NR				
	FL	Jacksonville	Fish	NR	No	Nemacur 10G	Golf Course/ Registered Use	Unknown
			Birds	NR				
07/28/91	FL	Orlando	Fish	NR	No	Nemacur 10G	Golf Course/Registered Use	Unknown
			Birds	NR				
07/22/91	FL	Naples	Fish	NR	No	Nemacur 10G	Golf Course/Registered Use	Unknown
			Birds	NR				
07/09/91	MO	St. Louis	Fish	NR	No	Fenamiphos/NR	Golf Course/NR	Probable
02/09/90	FL	Martin	Birds (robins and waxwings)	58	Yes	Nemacur 3/ Ground Spray	Turf/Undetermined	Highly Probable
10/01/81	OH	NR	Birds	NR	No	Fenamiphos/NR	Agricultural Area/NR	Probable
05/18/81	MO	Cape Giardeau	Fish	>1,000	No	Fenamiphos/NR	Golf Course/Registered Use	Highly Probable
09/01/77	TX	NR	Bird	1	No	Fenamiphos	Pyracanthus Bush/NR	Probable

\*NR means Not Reported

Incidents entered into EIIS are also categorized as to use/misuse. Unless specifically confirmed by a state or federal agency to be misuse, or there was very clear misuse such as intentional baiting to kill wildlife, incidents would not typically be considered misuse. Data entry personnel often do not have a copy of the specific label used in a given application, and would not usually be able to detect a variety of label-specific violations.

## APPENDIX E: EECs

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**Table E1. EECs of Fenamiphos on Food Items of Terrestrial Vertebrates (ppm)**

Crop/ Formulation	Maximum Single Application Rate (lb a.i./A) <sup>a</sup>	Maximum Seasonal Application Rate (lb a.i./A) <sup>a</sup>	Food Items	Maximum Residue EEC (ppm) <sup>b</sup>	Mean Residue EEC (ppm) <sup>b</sup>
Eggplant/ Nemacur 3	2.0	Not Specified But Assumed 2.0	Short grass	480	170
			Tall grass	220	72
			Broadleaf/forage plants, and small insects	270	90
			Fruits, pods, seeds, and large insects	30	14
Asparagus (CT, DE, ME, MA, NH, NJ, NY, PA, and RI only) <sup>e</sup> / Nemacur 3	2.0	2.0	Short grass	480	170
			Tall grass	220	72
			Broadleaf/forage plants, and small insects	270	90
			Fruits, pods, seeds, and large insects	30	14
Peanuts/ Nemacur 3	2.5 (1.2) <sup>d</sup>	Not Specified But Assumed 2.5 (1.2) <sup>d</sup>	Short grass	624 (288)	221 (102)
			Tall grass	>286 (132)	>94 (43)
			Broadleaf/forage plants, and small insects	351 (162)	117 (54)
			Fruits, pods, seeds, and large insects	39 (18)	18 (8.4)
Cotton/ Nemacur 3	3.0	Not Always Specified But Assumed 3.0	Short grass	720	255
			Tall grass	>330 <sup>c</sup>	>108 <sup>c</sup>
			Broadleaf/forage plants, and small insects	405	135
			Fruits, pods, seeds, and large insects	45	21
Table Beets (IL, IN, MI, NY, OH and PA only) <sup>e</sup> / Nemacur 3	3.1	3.1	Short grass	744	264
			Tall grass	>341	>112
			Broadleaf/forage plants, and small insects	419	140
			Fruits, pods, seeds, and large insects	47	22
Strawberries/ Nemacur 3	4.5	7.0	Short grass	1080	383
			Tall grass	>495	>162
			Broadleaf/forage plants, and small insects	>608	>202
			Fruits, pods, seeds, and large insects	68	32
Citrus (Certain Florida Counties) <sup>f</sup> / Nemacur 3	5.0	10.0	Short grass	1200	425
			Tall grass	>550	>180
			Broadleaf/forage plants, and small insects	>675	>225

**Table E1. EECs of Fenamiphos on Food Items of Terrestrial Vertebrates (ppm)**

Crop/ Formulation	Maximum Single Application Rate (lb a.i./A) <sup>a</sup>	Maximum Seasonal Application Rate (lb a.i./A) <sup>a</sup>	Food Items	Maximum Residue EEC (ppm) <sup>b</sup>	Mean Residue EEC (ppm) <sup>b</sup>
			Fruits, pods, seeds, and large insects	75	35
Tobacco/ Nemacur 3	6.0	Not Specified But Assumed 6.0	Short grass	1440	510
			Tall grass	>660	>216
			Broadleaf/forage plants, and small insects	>810	>270
			Fruits, pods, seeds, and large insects	90	42
Kiwi Fruit (California only),  Raspberries &  Grapes/ Nemacur 3	6.0	6.0	Short grass	1440	510
			Tall grass	>660	>216
			Broadleaf/forage plants, and small insects	>810	>270
			Fruits, pods, seeds, and large insects	90	42
Stone Fruits (peaches, cherries and nectarines)  Apple Nemacur 3	7.5	7.5	Short grass	>1800	>638
			Tall grass	>825	>270
			Broadleaf/forage plants, & small insects	>1012	>338
			Fruits, pods, seeds, and large insects	113	53
Citrus ( except Kumquat, Tangelo, and Citrus Hybrids in California; except Florida) Nemacur 3	7.5	7.5	Short grass	>1800	>638
			Tall grass	>825	>270
			Broadleaf/forage plants, and small insects	>1012	>338
			Fruits, pods, seeds, and large insects	113	53
Pineapple/ Nemacur 3	9.0	24.0	Short grass	>2160	>765
			Tall grass	>990	>324
			Broadleaf/forage plants, and small insects	>1215	>405
			Fruits, pods, seeds, and large insects	135	63
Turf/ Nemacur 3	9.9	19.8 (2 applications)	Short grass	>2376	>842
			Tall grass	>1089	>356
			Broadleaf/forage plants, and small insects	>1337	>446
			Fruits, pods, seeds, and large insects	149	69

<sup>a</sup>Maximum single application and seasonal application rates (lbs a.i./A) are from Appendix D for a given fenamiphos registered use.

<sup>b</sup>Modified Hoerger-Kenaga maximum and mean residue values for a 1 lb a.i./A application were used to calculate EECs for other application rates; calculations were performed as described in Section 3b.

<sup>c</sup>> Mean tall grass, short grass, and forage plants exceeded Hoerger-Kenaga values at application rates greater than 2.5, 6.0, and 4.0 lb a.i./A, respectively.

<sup>d</sup>Two rates are provided, rate for 10% of the crop is provided in parenthesis and the other represents the rate for approximately 90% of cotton use.

<sup>e</sup>CT = Connecticut; DE = Delaware; IL = Illinois; IN = Indiana; ME = Maine; MA = Massachusetts; MI = Michigan; NH = New Hampshire; NJ = New Jersey; NY = New York; OH = Ohio; PA = Pennsylvania; and RI = Rhode Island.

<sup>f</sup>Brevard, Broward, Charlotte, Citrus, Collier, Desoto, Glades, Hardee, Hendry, Hernando, Hillsborough, Indian River, Lee, Manatee, Marion, Martin, Okeechobee, Palm Beach, Pascoe, Pinellas, Putnam, St. Lucie, Sarasota, Seminole and Volusia.



**Table E2. Surficial Soil Fenamiphos EECs for Single Applications of Fenamiphos Granular Products.**

Site/Application Method Band Width (feet) Crop Row Spacing (ft)	% a.i.	Application Rate (oz of product/1,000 ft of row)	Application Rate <sup>a</sup> (lb a.i./A)	Application Rate <sup>b</sup> (mg a.i./ft <sup>2</sup> )	Percent of Pesticide Left on the Soil <sup>c</sup>	Exposed <sup>d</sup> (mg a.i./ft <sup>2</sup> )	Exposed <sup>e</sup> Granules/ft <sup>2</sup>
Cotton/At planting 1 3	15	12	1.6	51	15	7.7	582
Strawberries/Prior to planting 1.5 2	15	22	4.5	62.4	15	9.4	716
Eggplant & non-bell peppers/At planting 1 3	15	14.7	2.0	62.5	15	9.4	718
Okra/At planting 1.25 3.33	15	18.4	2.3	62.6	15	9.4	719
Bok choy, cabbage, & brussel sprouts/At planting 1.25 1.67	15	18.4	4.5	62.6	15	9.4	719
Bananas & plantains/ Established plants Not applicable Not applicable	15	Not applicable	6.8	70.8	1	0.7	54
Non-bearing strawberries & nursery stock/Pretransplant 1 2	15	17	3.5	72.3	15	10.8	828
Peanuts/At planting 1 3	15	18.7	2.5	79.5	15	11.9	912
Pineapple/Before planting Not applicable Not applicable	15	Not applicable	9.0	93.7	15	14.1	1,077
Leatherleaf fern, anthurium & nursery stock/Established plants Not applicable Not applicable	10	Not applicable	10	104	100	104	11,966
Turf/Established plants Not applicable Not applicable	10	Not applicable	10	104	100	104	11,966
Iris, lily & narcissus bulbs/ Established plants 1 3.5	10	128	10	363	15	54	6,253
Garlic/At planting 0.1 1.67	15	18.4	4.5	782	1	7.8	598

<sup>a</sup>Application rates in lbs a.i./A are from Appendix D.

<sup>b</sup>Application Rate (mg a.i./ft<sup>2</sup> within band) = [Application Rate (lb a.i./A) \* 453,590 mg/lb] ÷ [(43,560 (ft<sup>2</sup>/A) ÷ Crop Row Spacing (ft)) \* Band Width (ft)]

Application Rate for Broadcast (mg a.i./ft<sup>2</sup>) = [Application Rate (lb a.i./A) \* 453,590 mg/lb] ÷ [43,560 (ft<sup>2</sup>/A)]

<sup>c</sup>Incorporation efficiency (f<sub>efficiency</sub>): Banded (covered with specified amount of soil), in-furrow, drill or shanked-in = 99%

Side-dress, banded or broadcast (all mixed or lightly incorporated with soil) = 85%

Side-dress, banded, broadcast, aerial broadcast (all unincorporated) = 0%

<sup>d</sup>Exposed (mg a.i./ft<sup>2</sup> within the band) = Application Rate (mg a.i./ft<sup>2</sup> within band) \* (1 - f<sub>efficiency</sub>)

Exposed for Broadcast (mg a.i./ft<sup>2</sup>) = Application Rate for Broadcast (mg a.i./ft<sup>2</sup>) \* (1 - f<sub>efficiency</sub>)

<sup>e</sup>Exposed granules (no./ft<sup>2</sup>) = Exposed substance (mg a.i./ft<sup>2</sup>) ÷ (x mg a.i./1 mg of product \* 0.087 mg product/1 granule)

## APPENDIX F: Laboratory Toxicity Studies and Results

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**Table F1. Avian Acute Oral Toxicity Findings (LD<sub>50</sub>) -- Fenamiphos Technical and Nemacur 3 End-Use Formulation**

Surrogate Species	% a.i	LD <sub>50</sub> (mg a.i./kg-bw)	Toxicity Category	MRID No. Author/Year	Study Classification <sup>a</sup>
<b>Fenamiphos Technical</b>					
Bobwhite Quail ( <i>Colinus virginianus</i> )	90.0	1.6	very highly toxic	00121289/ACC 071291 D.W. Lamb/1982	Core
Canary ( <i>Serinus canarius</i> )	81.6	0.5 to 1.0	very highly toxic	ACC 120301/Inst. for Toxicology/Leverkusen- Bayerwerk,W. Germany/1968	Supplemental
Pigeon ( <i>Columba livia</i> )	81.6	0.5 to 1.0	very highly toxic	ACC 120301/Inst. for Toxicology/Leverkusen- Bayerwerk,W. Germany/1968	Supplemental
Mallard Duck ( <i>Anas platyrhynchos</i> )	81.0	1.68	very highly toxic	ACC 091689/R. H. Hudson/ Denver Wildlife Research Center/1972	Supplemental
Domestic Chicken (species unknown)	80.0	10.0 to 15.0	highly toxic	001310 & 00154492/Bayer Agricultural Inst./1992	Supplemental
Domestic Chicken (species unknown)	Technical, % Not Reported	5.31, female	very highly toxic	112414/Bayer Agricultural Inst./1992	Supplemental
Ring-necked Pheasant ( <i>Phasianus colchicus</i> )	81.0	0.5 to 1.0	very highly toxic	ACC 091689/R. H. Hudson/ Denver Wildlife Research Center/1972	Supplemental
<b>Nemacur 3 End-Use Formulation</b>					
Mallard Duck ( <i>Anas platyrhynchos</i> )	35.0	2.5 to 3.0 male & female	very highly toxic	ACC 091689/Keichline & Bradburn/1969	Supplemental
Bobwhite Quail ( <i>Colinus virginianus</i> )	35.0	0.8, male 0.9, female	very highly toxic	ACC 091689/ Keichline & Bradburn/1969	Supplemental

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F2. Avian Subacute Dietary Toxicity Findings (LC<sub>50</sub>) Fenamiphos Technical**

Surrogate Species	% a.i.	LC <sub>50</sub> (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification <sup>a</sup>
Northern Bobwhite Quail ( <i>Colinus virginianus</i> )	88.0	38	very highly toxic	0025959/ Nelson & Burke/ 1977	Core
Mallard Duck ( <i>Anas platyrhynchos</i> )	88	316	highly toxic	0025958/ J. B. Beavers, Fink & Brown/1977	Core
Japanese Quail	Not Reported	59	highly toxic	0022923/ Hill et al./1975	Supplemental

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F3. Avian Reproduction -- Fenamiphos Technical**

Surrogate Species/ Study Duration	% a.i.	NOAEL/LOAEL (ppm)	LOAEL Endpoints	MRID No. Author/Year	Study Classification <sup>a</sup>
Northern Bobwhite Quail ( <i>Colinus virginianus</i> )/ 25 weeks	90.0	2.0/8.0	14-Day Hatchling Survival	121291/ ACC 071291 D. W. Lamb & M. A. Carsel/1982	Core
Mallard Duck ( <i>Anas platyrhynchos</i> )/ 14 weeks	90.0	8.0/16.0	Egg Shell Thickness, Egg Production, Embryo & 14- Day Hatchling Survival	121290/ ACC 071291 D. W. Lamb & M. A. Carsel/1982	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements.

**Table F4. Mammalian Acute Oral Toxicity Findings (LD<sub>50</sub>) -- Fenamiphos Technical**

Surrogate Species	% a.i.	LD <sub>50</sub> (mg/kg)	Toxicity Category	MRID No.	Study Classification <sup>a</sup>
Laboratory Rat ( <i>Rattus norvegicus</i> )	99.7	3.15, male 2.38, female	very highly toxic	06F1693	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )	85	8.1, male 4.75, female	very highly toxic	0001308 & 0001310/Bayer Agricultural Inst./1992	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )	88.0	2.7, male 3.0, female	very highly toxic	00033831/ACC 099496/Mobay Chemical Company/1975	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )	88.0	2.4, male 3.3, female	very highly toxic	00052532/Mobay Chemical Company/1974	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )	80.0	8.1, male 9.6, female	very highly toxic	0001308 & 0001310/Bayer Agricultural Inst./1992	Core
Laboratory Mouse ( <i>Mus musculus</i> )	80.0	8.3, female	very highly toxic	0001308/Bayer Agricultural Inst./1992	Core
Guinea pig ( <i>Cavia porcellus</i> )	80.0	>75.0 and <100.0	moderately toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
Guinea pig ( <i>Cavia porcellus</i> )	80.0	55.90	moderately toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )	80.0	5.00	very highly toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
Domestic Cat ( <i>Felis domestica</i> )	80.0	2.5 to 10.0	highly toxic to very highly toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
Domestic Dog ( <i>Canis familiaris</i> )	80.0	>2.5	very highly toxic	00154492/Bayer Agricultural Inst./1992	Supplemental

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F5. Mammalian Acute Oral Toxicity Findings (LD<sub>50</sub>) – End-Use Formulations, Metabolites, and Degradates**

Surrogate Species/ Formulation	% a.i.	LD <sub>50</sub> (mg/kg)	Toxicity Category	MRID No.	Study Classification <sup>a</sup>
<b>Nemacur 3, 10G &amp; 15G End-Use Formulations</b>					
Laboratory Rat ( <i>Rattus norvegicus</i> ) Nemacur 15G	15.0	10.0, male fasted 45.0, male nonfasted 14.0, female fasted 61.0, female nonfasted	moderately to highly toxic	099496/Mobay Chemical Company/1974	Core
Laboratory Rat ( <i>Rattus norvegicus</i> ) Nemacur 3	35.6	25.0, female	highly toxic	0064611/Bayer AG Institute/1992	Core
Laboratory Rat ( <i>Rattus norvegicus</i> ) Nemacur 3	35.0	24.8, male	highly toxic	001311/Univ. of Chicago/1989	Supplemental
Laboratory Rat ( <i>Rattus norvegicus</i> ) Nemacur 15G	15.0	66.6, male 62.7, female	moderately toxic	001311/Univ. of Chicago/1989	Supplemental
Laboratory Rat ( <i>Rattus norvegicus</i> ) Nemacur 10G	10.0	100.0	moderately toxic	00154492 and 001310/Bayer AG Institute/1992	Supplemental

**Table F5. Mammalian Acute Oral Toxicity Findings (LD<sub>50</sub>) – End-Use Formulations, Metabolites, and Degradates**

Surrogate Species/ Formulation	% a.i.	LD <sub>50</sub> (mg/kg)	Toxicity Category	MRID No.	Study Classification <sup>a</sup>
<b>Environmental Degradates/Mammal Metabolites</b>					
Laboratory Rat ( <i>Rattus norvegicus</i> ) MTMC Sulfoxide Metabolite	% Not Reported	1418, male 1175, female	slightly toxic	00052532/Mobay Chemical Company/1974	Core
Laboratory Rat ( <i>Rattus norvegicus</i> ) MTMC Sulfone Metabolite	95.0	1250, male 1854, female	slightly toxic	00052532/Mobay Chemical Company/1974	Core
Laboratory Rat ( <i>Rattus norvegicus</i> ) Deisopropyl Fenamiphos Sulfoxide Metabolite	95.0	4.1, male 3.7, female	very highly toxic	00099496/Mobay Chemical Company/1975	Core
Laboratory Rat ( <i>Rattus norvegicus</i> ) Fenamiphos Sulfone Metabolite & Environmental Degradate	% Not Reported	2.6, male	very highly toxic	00040215/Mobay Chemical Company/ Date Not Reported	Core
Laboratory Rat ( <i>Rattus norvegicus</i> ) 4-Methyl-mercapto-m-cresol Metabolite	% Not Reported	1,418, male 1,333, female	slightly toxic	00039700/Mobay Chemical Company/1974	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F6. Mammalian Dermal Toxicity (LD<sub>50</sub>) -- Fenamiphos Technical and End-Use Formulations**

Surrogate Species/ Formulation	% a.i.	LD <sub>50</sub> (mg/kg)	Toxicity Category	MRID No.	Study Classification <sup>a</sup>
<b>Technical</b>					
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )/ Technical	% Not Reported	225, male 178.8, female	highly toxic to very highly toxic	00037962/ Mobay Chemical./1972	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )/ Technical	80.0	72.9, male 84.3, female	very highly toxic	00001310 & 0000154492 /Bayer AG Institute/1992	Supplemental
<b>End-Use Formulations</b>					
Laboratory Rat ( <i>Rattus norvegicus</i> )/ Nemacur 3	35.6	154.2, male 119.4, female	very highly toxic	00001310 & 0000154492 /Bayer AG Institute/1992	Supplemental
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )/ Nemacur 15G	15.0	>1,000	highly toxic	001G1168 & ACC 005722 /Mobay Chemical Company/1974	Supplemental
Laboratory Rat ( <i>Rattus norvegicus</i> )/ Nemacur 15G	15.0	>2,000, male & female	moderately to slightly toxic	42476001/ Miles Laboratories/1992	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.



**Table F7. Mammalian Inhalation Toxicity (LC<sub>50</sub>) -- Fenamiphos Technical and End-Use Formulations**

Surrogate Species/ Formulation	% a.i.	LC <sub>50</sub>	Toxicity Category	MRID No.	Study Classification <sup>a</sup>
<b>Technical</b>					
Laboratory Rat ( <i>Rattus norvegicus</i> )/Technical	80.00	0.18 mg/L/1 hr	very highly toxic	00001310 & 0000154492/ Bayer AG Institute/1992	Supplemental
Laboratory Rat ( <i>Rattus norvegicus</i> )/Technical	80.00	0.15 mg/L/1 hr	very highly toxic	00001310 & 0000154492/ Bayer AG Institute/1992	Supplemental
Laboratory Rat ( <i>Rattus norvegicus</i> )/Technical	80.00	0.02 mg/L/4 hr	very highly toxic	00001310 & 0000154492/ Bayer AG Institute/1992	Supplemental
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )/Technical	80.00	>0.23 mg/L/1 hr	highly toxic	0000154492/Bayer AG Institute/1992	Supplemental
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )/Technical	80.00	>0.02 mg/L/4 hr	very highly toxic	0000154492/Bayer AG Institute/1992	Supplemental
Guinea pig ( <i>Cavia porcellus</i> )/Technical	80.0	>0.23 mg/L/1 hr	highly toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
Guinea pig ( <i>Cavia porcellus</i> )/Technical	80.0	0.02 mg/L/4 hr	very highly toxic	00154492/Bayer AG Inst./1992	Supplemental
Laboratory Mouse ( <i>Mus musculus</i> )/Technical	80.0	0.15 mg/L/1 hr	very highly toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
Laboratory Mouse ( <i>Mus musculus</i> )/Technical	80.0	0.02 mg/L/4 hr	very highly toxic	00154492/Bayer Agricultural Inst./1992	Supplemental
<b>Nemacur 3 and 15G</b>					
Laboratory Rat ( <i>Rattus norvegicus</i> )/Nemacur 3	35.00	1.7 mg/L/1 hr	highly toxic	001G1168/Univ. of Chicago/1989	Supplemental
Laboratory Rat ( <i>Rattus norvegicus</i> )/Nemacur 15G	15.00	> 20 mg/L/1 hr	slightly toxic	00001311/Chemgro/1990	Supplemental

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F8. Mammalian Subchronic Toxicity Findings -- Fenamiphos Technical**

Surrogate Species/ Exposure Duration	% a.i.	NOAEL/LOAEL (ppm)	LOAEL Endpoints	MRID No. Author/Year	Study Classification <sup>a</sup>
Laboratory rat ( <i>Rattus norvegicus</i> )/ 2 years	78	10.0/30.0 for Systemic Effects  3.0/10.0 for Cholinesterase Depression	Increased mortality, increased lung and thyroid gland weights  Cholinesterase inhibition	00112414/ Bayer AG Institute/1972	Core
Domestic Dog ( <i>Canis familiaris</i> )	78	>10.0/Not Recorded for Systemic Effects  1.0/2.0 for Cholinesterase Depression	Anemia in males  Cholinesterase inhibition	00112414/ Bayer AG Institute/1972	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F9. Mammalian Developmental and Reproductive Toxicity Findings -- Fenamiphos Technical**

Surrogate Species/ Exposure Duration	% a.i.	NOAEL/LOAEL (ppm)	LOAEL Endpoints	MRID No. Author/Year	Study Classification <sup>a</sup>
<b>Developmental Effects</b>					
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )	91.0	16.5/82.5 <sup>b</sup>	Fused ribs, abnormally shaped sternabrae, absence of rib # 3	40347602/ Research & Consulting	Core
Laboratory Rabbit ( <i>Sylvilagus sp.</i> )	88.0	9.9/33 <sup>b</sup>	Chained fused sternabrae and mortality	00071290/ Hazelton Raltech/1982	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )	88.7	60 <sup>b</sup> /Not Recorded	Pup development was not recorded/Maternal LEL is 60 with weight loss and signs of toxicity.	41225401/ Miles Laboratories/1989	Core
<b>Reproductive Effects</b>					
Laboratory Rat ( <i>Rattus norvegicus</i> )/ 3-generation	78.8	10 ppm / 30 ppm	Systemic NOAEL = 10 ppm, with Systemic LEL = 30 ppm, decreased weight gain in F2 generation males.	00112414/ Bayer Ag Institute/1972	Core
Laboratory Rat ( <i>Rattus norvegicus</i> )/ 2-generation	89.0	2.5 ppm/ 10 ppm	Reduced body weight gain in F0 and F1 rats. Significant cholinesterase depression in parents and offspring at 10 and 40	42491701/ Mobay Chemical Company/1991	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

<sup>b</sup>Values reported as mg/kg-bw/day in the study were converted to ppm of diet using 1mg/kg-bw/day = 20 ppm in adult rats and 33 ppm in rabbits (Nelson, 1975)

**Table F10. Nontarget Insect Acute Contact Toxicity Findings -- Fenamiphos Technical**

Surrogate Species	% a.i.	LD <sub>50</sub> (µg/bee)	Toxicity Category	MRID No. Author/Year	Study Classification <sup>a</sup>
Domesticated Honey Bee ( <i>Apis mellifera</i> )	Not Reported	1.87	Highly toxic	00036935/ Atkins et al./1975	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements.

**Table F11. Freshwater Fish Acute Toxicity Findings -- Fenamiphos Technical and End-Use Formulations**

Surrogate Species/ Formulation	% a.i.	LC <sub>50</sub> (C.I.) <sup>a</sup> (ppb) <sup>b</sup>	Toxicity Category	MRID No. Author/Year	Study Classification <sup>c</sup>
<b>Technical</b>					
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/Technical	88.0	9.5 (6.8-15.0)	very highly toxic	00025962/Lamb & Roney/1977	Core
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/Technical	81.0	17.7 (14.4-21.6)	very highly toxic	00114012/Lamb & Roney/1972	Core
Rainbow Trout ( <i>Oncorhynchus sp.</i> )/ Technical	81.0	72.1 (61.2-84.7)	very highly toxic	00114012/Lamb & Roney/1972	Core
<b>Nemacur 3 and 15G</b>					
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/ Nemacur 3	36.0	4.5 (3.9-5.1) NOEC = 1.7	very highly toxic	40799704/D. Surprenant/1988	Core
Rainbow Trout ( <i>Salmo gairdneri</i> )/ Nemacur 3	36.0	68.0 (59.6-77.1)	very highly toxic	40799701/D. Surprenant/1988	Core
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/Nemacur 15G	15.0	151 (114-201)	highly toxic	00114012/ Lamb & Roney/1972	Core
Rainbow Trout ( <i>Oncorhynchus sp.</i> )/ Nemacur 15G	15.0	563 (454-698)	highly toxic	00114012/ Lamb & Roney/1972	Core
<b>Degradates/Metabolites</b>					
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/Fenamiphos sulfone	%Not Reported	1,173 / (1,000-1,500)	moderately toxic	00025962/Lamb & Roney/1977	Supplemental
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/Fenamiphos sulfoxide	% Not Reported	2,653/ (1,000-4,600)	moderately toxic	00025962/Lamb & Roney/1977	Supplemental
Bluegill Sunfish ( <i>Lepomis macrochirus</i> )/Fenamiphos sulfoxide	99.0	2,000/ (1,800-2,300)	moderately toxic	00114015/Lamb & Roney/1972	Supplemental

<sup>a</sup>(C.I.) = Confidence Intervals

<sup>b</sup> 1 ppm = 1,000 ppb

<sup>c</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F12. Freshwater Fish Early Life-Stage Toxicity Under Flow-through Conditions -- Fenamiphos Technical**

Species	% a.i.	NOEC/LOEC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classification <sup>a</sup>
Rainbow Trout ( <i>Salmo gairdneri</i> )	88.7	3.8/7.4	larval length and weight	41064301/D. Surprenant/1989	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements.

**Table F13. Acute Freshwater Invertebrate Toxicity Findings -- Fenamiphos Technical and Nemacur 3**

Surrogate Species	% a.i.	LC <sub>50</sub> /EC <sub>50</sub> (C.I.) <sup>a</sup> (ppb) <sup>b</sup>	Toxicity Category	MRID No. Author/Year	Study Classification <sup>c</sup>
<b>Technical</b>					
Daphnid ( <i>Daphnia magna</i> ) Technical	88.7	1.9 (1.7-2.1) NOEC < 1.0	very highly toxic	40799706/D. Surprenant/1988	Core
<b>Nemacur 3</b>					
Daphnid ( <i>Daphnia magna</i> ) Nemacur 3	36	1.3 NOEC = 0.8	very highly toxic	43183501/ D. Surprenant/1990	Core
<b>Degradates/Metabolites</b>					
Daphnid ( <i>Daphnia magna</i> ) Fenamiphos sulfoxide	% Not Reported	7.5 (6.0-14.4)	very highly toxic	41497701/ Mobay Chemical Company/1990	Supplemental

<sup>a</sup>(C.I.) = Confidence Intervals

<sup>b</sup> 1 ppm = 1,000 ppb

<sup>c</sup>Core means the study is scientifically sound and satisfies guideline requirements. Supplemental means the study is scientifically sound but does not satisfy guidelines.

**Table F14. Freshwater Aquatic Invertebrate Life-Cycle Toxicity -- Fenamiphos Technical**

Species/Static Renewal	% a.i.	21-day NOEC/LOEC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classification <sup>a</sup>
Waterflea ( <i>Daphnia magna</i> )	99.6	0.12/0.24	Reproduction (Number of neonates/reproductive day and mean body length.)	43121401 & 40922201/ D. Surprenant/1988 & 1994	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements.

**Table F15. Estuarine/Marine Acute Toxicity Findings -- Fenamiphos Technical**

Surrogate Species	% a.i.	LC <sub>50</sub> /EC <sub>50</sub> (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification <sup>a</sup>
Eastern Oyster (shell deposition or embryo-larvae) ( <i>Crassostrea virginica</i> ) Shell Deposition	88.7	EC <sub>50</sub> =1,650 NOEC=630	moderately toxic	40799709/D. Surprenant/1988	Core
Sheepshead Minnow ( <i>Cyprinodon variegatus</i> )	88.7	LC <sub>50</sub> =17.0	very highly toxic	40799710/D. Surprenant/1988	Core
Mysid Shrimp ( <i>Mysidopsis bahia</i> )	88.7	LC <sub>50</sub> =6.2	very highly toxic	40799708/D. Surprenant/1988	Core

<sup>a</sup>Core means the study is scientifically sound and satisfies guideline requirements.

## APPENDIX G: Terrestrial Wildlife and Aquatic Organism RQs by Fenamiphos Use

Table G1. Avian (Reptilian & Terrestrial-Phase Amphibians) Acute and Chronic RQs for Single Applications of Nemacur 3 Based on a Bobwhite Quail  $LC_{50}$  of 38 ppm and Reproduction NOAEL of 2 ppm. . . . . 100

Table G2. Avian Acute RQs for Single Applications of Fenamiphos Granular Products Based on a Bobwhite Quail  $LD_{50}$  of 1.6 mg a.i./kg-bw. . . . . 102

Table G3: Mammalian [Herbivore/Insectivore/Granivore (H/I/G)] Acute and Chronic RQs for Fenamiphos, Based on a Rat Acute Oral  $LD_{50}$  of 2.38 mg/kg-bw and a Reproductive NOAEL of 2.5 ppm, for Single Applications of Nemacur 3. . . . . 103

Table G4: Mammalian [(Herbivore/Insectivore/Granivore (H/I/G))] Acute RQs for Fenamiphos Sulfone, based on a Rat Acute Oral  $LD_{50}$  of 2.6 mg/kg for Fenamiphos Sulfone, from a Single Application of Nemacur 3. . . . . 107

Table G5. Mammalian Acute RQs, Based on a Laboratory Rat  $LD_{50}$  of 2.3 mg a.i./kg-bw/day, for Single Applications of Fenamiphos Granular Products. . . . . 111

**Table G1. Avian (Reptilian & Terrestrial-Phase Amphibians) Acute and Chronic RQs for Single Applications of Nemacur 3 Based on a Bobwhite Quail  $LC_{50}$  of 38 ppm and Reproduction NOAEL of 2 ppm.**

Crop/ Formulation	Maximum Single Application Rate <sup>a</sup> (lb a.i./A)	Food Items	Maximum Residue EEC <sup>b</sup> (ppm)	Mean Residue EEC <sup>b</sup> (ppm)	Maximum Acute RQ <sup>c</sup>	Mean Acute RQ <sup>d</sup>	Maximum Chronic RQ <sup>e</sup>	Mean Chronic RQ <sup>f</sup>
Asparagus (CT, DE, ME, MA, NH, NJ, NY, PA, and RI only) Eggplant Nemacur 3	2.0	Short grass	480	170	13	4.5	240	85
		Tall grass	220	72	5.8	1.9	110	36
		Broadleaf forage plants, and small insects	270	90	7.1	2.4	135	45
		Fruits, pods, seeds, and large insects	30	14	0.79	0.37	15	7.0
Peanuts Nemacur 3	2.5 (1.2) <sup>b</sup>	Short grass	624 (288)	221 (102)	16 (7.6)	5.8 (2.7)	312 (144)	110 (51)
		Tall grass	>286 (132)	>94 (43)	>7.5 (3.5)	>2.5 (1.1)	>143 (66)	>47 (22)
		Broadleaf forage plants and small insects	351 (162)	117 (54)	9.2 (4.3)	3.1 (1.4)	176 (81)	58 (27)
		Fruits, pods, seeds, and large insects	39 (18)	18 (8.4)	1.0 (0.5)	0.48 (0.22)	20 (9.0)	9.1 (4.2)
Cotton Nemacur 3	3.0	Short grass	720	255	19	6.7	360	128
		Tall grass	>330 <sup>g</sup>	>108	>8.7	>2.8	>165	>54
		Broadleaf forage plants and small insects	405	135	11	3.6	203	68
		Fruits, pods, seeds and large insects	45	21	1.2	0.6	23	11
Table Beets (IL, IN, MI, NY, OH and PA only) Nemacur 3	3.1	Short grass	744	264	20	6.9	372	132
		Tall grass	>341 <sup>g</sup>	>112	>9.0	>2.9	>170	>56
		Broadleaf forage plants, & small insects	419	140	11	3.7	209	70
		Fruits, pods, seeds, and large insects	47	22	1.2	0.57	23	11



**Table G1. Avian (Reptilian & Terrestrial-Phase Amphibians) Acute and Chronic RQs for Single Applications of Nemacur 3 Based on a Bobwhite Quail LC<sub>50</sub> of 38 ppm and Reproduction NOAEL of 2 ppm.**

Crop/ Formulation	Maximum Single Application Rate <sup>a</sup> (lb a.i./A)	Food Items	Maximum Residue EEC <sup>b</sup> (ppm)	Mean Residue EEC <sup>b</sup> (ppm)	Maximum Acute RQ <sup>c</sup>	Mean Acute RQ <sup>d</sup>	Maximum Chronic RQ <sup>e</sup>	Mean Chronic RQ <sup>f</sup>
Strawberry Nemacur 3	4.5	Short grass	1080	383	28	10	540	191
		Tall grass	>495	>162	>13	>4.3	>248	>81
		Broadleaf/forage plants, & small insects	>607	>202	>16	>5.3	>304	>101
		Fruits, pods, seeds, and large insects	68	32	1.8	0.83	34	16
Citrus (Certain Florida Counties) Nemacur 3	5.0	Short grass	1200	425	32	11	600	>213
		Tall grass	>550	>180	>14	>4.7	>275	>90
		Broadleaf/forage plants, and small insects	>675	>225	>18	>5.9	>338	>113
		Fruits, pods, seeds, and large insects	75	35	2.0	0.92	38	18
Tobacco Nemacur 3	6.0	Short grass	1440	510	38	13	720	255
		Tall grass	>660	>216	>17	>5.7	>330	>108
		Broadleaf forage plants and small insects	>810	>270	>21	>7.1	>405	>135
		Fruits, pods, seeds, and large insects	90	42	2.4	1.1	45	21
Kiwi Fruit (CA only), Raspberry & Grapes Nemacur 3	6.0	Short grass	1440	510	38	13	720	255
		Tall grass	>660	>216	>17	>5.7	>330	>108
		Broadleaf/forage plants, & small insects	>810	>270	>21	>7.1	>405	>135
		Fruits, pods, seeds, and large insects	90	42	2.4	1.1	45	21
Stone Fruits (peaches &cherries & nectarines) Apple Nemacur 3	7.5	Short grass	>1800	>638	>47	>17	>900	>319
		Tall grass	>825	>270	>22	>7.1	>412	>135
		Broadleaf forage plants and small insects	>1012	>338	>27	>8.9	>506	>169
		Fruits, pods, seeds and large insects	113	53	3.0	1.4	56	26
Citrus (except Florida, except Kumquat, Tangelo, and Citrus Hybrids in California) Nemacur 3	7.5	Short grass	>1800	>638	>47	>17	>900	>319
		Tall grass	>825 <sup>g</sup>	>270	>22	>7.1	>412	>135
		Broadleaf/forage plants, and small insects	>1012	>338	>27	>8.9	>506	>169
		Fruits, pods, seeds, and large insects	113	53	3.0	1.4	56	26
Pineapple Nemacur 3	9.0	Short grass	>2160	>765	>57	>20	>1080	>382
		Tall grass	>990	>324	>26	>8.5	>495	>162
		Broadleaf/forage plants, & small insects	>1215	>405	>32	>11	>608	>202
		Fruits, pods, seeds, and large insects	135	63	3.6	1.7	68	32
Turf Nemacur 3	9.9	Short grass	>2376	>842	>63	>22	>1188	>421
		Tall grass	>1089	>356	>29	>9	>545	>178
		Broadleaf forage plants, & small insects	>1337	>446	>35	>12	>669	>223
		Fruits, pods, seeds, and large insects	149	69	3.9	1.8	74	7.0

**Table G1. Avian (Reptilian & Terrestrial-Phase Amphibians) Acute and Chronic RQs for Single Applications of Nemacur 3 Based on a Bobwhite Quail LC<sub>50</sub> of 38 ppm and Reproduction NOAEL of 2 ppm.**

Crop/ Formulation	Maximum Single Application Rate <sup>a</sup> (lb a.i./A)	Food Items	Maximum Residue EEC <sup>b</sup> (ppm)	Mean Residue EEC <sup>b</sup> (ppm)	Maximum Acute RQ <sup>c</sup>	Mean Acute RQ <sup>d</sup>	Maximum Chronic RQ <sup>e</sup>	Mean Chronic RQ <sup>f</sup>
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Note: Shaded acute RQ cells indicate that the acute risk, acute restricted use and acute endangered species LOCs are exceeded. Shaded chronic RQ cells indicate that the chronic risk LOC is exceeded.

<sup>a</sup>Maximum single application rates are from Appendix B.

<sup>b</sup>Maximum and mean residue EECs are from Appendix E.

<sup>c</sup>Maximum Acute RQ = (Maximum Residue EEC [ppm]) ÷ (LD<sub>50</sub> [ppm])

<sup>d</sup>Mean Acute RQ = (Mean Residue EEC [ppm]) ÷ (LD<sub>50</sub> [ppm])

<sup>e</sup>Maximum Chronic RQ = (Maximum Residue EEC [ppm]) ÷ (NOAEL [ppm])

<sup>f</sup>Mean Chronic RQ = (Mean Residue EEC [ppm]) ÷ (NOAEL [ppm])

<sup>g</sup>> symbol means tall grass, short grass, and forage plants exceeded Hoerger-Kenaga values at application rates greater than 2.5, 6.0, and 4.0 lb a.i./A, respectively.

<sup>h</sup>The values in parentheses represent application at 72-inch, double-row bed spacing the other value represents 36-inch, single-row spacing.

**Table G2. Avian Acute RQs for Single Applications of Fenamiphos Granular Products Based on a Bobwhite Quail LD<sub>50</sub> of 1.6 mg a.i./kg-bw.**

Site/Application Method Band Width (feet) Crop Row Spacing (feet)	% a.i.	Application Rate (oz of product/1,000 ft of row)	Application Rate <sup>a</sup> (lb a.i./A)	Application Rate <sup>b</sup> (mg a.i./ft <sup>2</sup> )	Percent of Pesticide Left on the Soil <sup>c</sup>	Exposed <sup>d</sup> (mg a.i./ft <sup>2</sup> )	Exposed <sup>e</sup> Granules/ft <sup>2</sup>	Body Weight (grams)	Acute RQ/ft <sup>2g,f</sup>
Cotton/At planting 1 3	15	12	1.6	50	15	7.7	582	20 180 1000	239 27 5.0
Strawberries/Prior to planting 1.5 2	15	22	4.5	62.5	15	9.4	716	20 180 1000	292 32 6
Eggplant & non-bell peppers/At planting 1 3	15	14.7	2.0	62.5	15	9.4	718	20 180 1000	293 33 6.0
Okra/At planting 1.25 3.33	15	18.4	2.3	63.8	15	9.4	719	20 180 1000	293 33 6
Bok choy, cabbage, & brussel sprouts/At planting 1.25 1.67	15	18.4	4.5	62.6	15	9.4	719	20 180 1000	293 33 6.0
Bananas & plantains/ Established plants Not applicable Not applicable	15	Not applicable	6.8	70.8	1	0.7	54	20 180 1000	22 2.0 0.4
Non-bearing strawberries & nursery stock/Pretransplant 1 2	15	17	3.5	72.9	15	10.8	828	20 180 1000	339 38 7
Peanuts/At planting 1 3	15	18.7	2.5	79.5	15	11.9	912	20 180 1000	373 41 7.0
Pineapple/Before planting Not applicable Not applicable	15	Not applicable	9.0	93.7	15	14.1	1,077	20 180 1000	439 49 9
Leatherleaf fern, anthurium & nursery stock/Established plants Not applicable Not applicable	10	Not applicable	10	104	100	104	11,966	20 180 1000	3,254 362 65
Turf/Established plants Not applicable Not applicable	10	Not applicable	10	104	100	104	11,966	20 180 1000	3,254 362 65
Iris, lily & narcissus bulbs/ Established plants 1 3.5	10	128	10	363	15	54	6,253	20 180 1000	1,701 189 34

Garlic/At planting 0.1 1.67	15	18.4	4.5	782	1	7.8	598	20 180 1000	245 27 5.0
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Note: Shaded acute RQ cells indicate that the acute risk, acute restricted use and acute endangered species LOCs are exceeded.

<sup>a</sup>Application rates in lbs a.i./A are from Appendix B.

<sup>b</sup>Application Rate (mg a.i./ft<sup>2</sup> within band) = [Application Rate (lb a.i./A) \* 453,590 mg/lb] ÷ [(43,560 (ft<sup>2</sup>/A) ÷ Crop Row Spacing (ft)) \* Band Width (ft)]

Application Rate for Broadcast (mg a.i./ft<sup>2</sup>) = [Application Rate (lb a.i./A) \* 453,590 mg/lb] ÷ 43,560 (ft<sup>2</sup>/A)

<sup>c</sup>Incorporation efficiency: Banded (covered with specified amount of soil), in-furrow, drill or shanked-in = 99%

Side-dress, banded or broadcast (all mixed or lightly incorporated with soil) = 85%

Side-dress, banded, broadcast, aerial broadcast (all unincorporated) = 0%

<sup>d</sup>Exposed (mg a.i./ft<sup>2</sup> within the band) = Application Rate (mg a.i./ft<sup>2</sup> within band) \* (1 - Incorporation efficiency)

Exposed for Broadcast (mg a.i./ft<sup>2</sup>) = Application Rate for Broadcast (mg a.i./ft<sup>2</sup>) \* (1 - Incorporation efficiency)

<sup>e</sup>RQ = Exposed (mg a.i./ft<sup>2</sup>) ÷ [LD<sub>50</sub> (mg a.i./kg-bw) \* Body weight (grams) \* 1 kg/1000 grams]

<sup>f</sup>RQ values exceeding levels of concern are shaded.

<sup>g</sup>Exposed granules (no./ft<sup>2</sup>) = Exposed substance (mg a.i./ft<sup>2</sup>) ÷ (x lbs a.i./1 lb of product \* 0.087 mg/granule) from Balcomb, et al. (1984).

**Table G3: Mammalian [Herbivore/Insectivore/Granivore (H/I/G)] Acute and Chronic RQs for Fenamiphos, Based on a Rat Acute Oral LD<sub>50</sub> of 2.38 mg/kg-bw and a Reproductive NOAEL of 2.5 ppm, for Single Applications of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./ A) <sup>a</sup>	Food Items	Maximum Residue EEC <sup>b</sup> (mg/kg)	Mean Residue EEC <sup>b</sup> (mg/kg)	Body Weight (grams) <sup>c</sup>	I <sub>bw</sub> (H/I) <sup>d</sup>	Max. Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	I <sub>bw</sub> (G) <sup>d</sup>	Max. Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>	Max Chronic RQ <sup>g</sup>	Mean Chronic RQ <sup>h</sup>
Asparagus (CT, DE, ME, MA, NH, NJ, NY, PA, and RI only)  Eggplant  Nemacur 3	2.0	Short grass	480	170	15	0.95	192	68	n/a	n/a	n/a	192	68
			480	170	35	0.66	133	47	n/a	n/a	n/a	192	68
			480	170	1,000	0.15	30	11	n/a	n/a	n/a	192	68
		Tall grass	220	72	15	0.95	88	29	n/a	n/a	n/a	88	29
			220	72	35	0.66	61	20	n/a	n/a	n/a	88	29
			220	72	1,000	0.15	14	5	n/a	n/a	n/a	88	29
		Broadleaf forage plants, and small insects	270	90	15	0.95	108	36	n/a	n/a	n/a	108	36
			270	90	35	0.66	75	25	n/a	n/a	n/a	108	36
			270	90	1,000	0.15	17	5.7	n/a	n/a	n/a	108	36
		Fruits, pods, seeds, and large insects	30	14	15	0.95	12	5.6	0.21	2.6	1.2	12	5.6
			30	14	35	0.66	8.3	3.9	0.15	2.0	0.9	12	5.6
			30	14	1,000	0.15	1.9	0.9	0.03	0.4	0.2	12	5.6
Peanuts Nemacur 3	2.5 (1.2)	Short grass	624 (288)	221 (102)	15	0.95	249 (115)	88 (47)	n/a	n/a	n/a	250 (115)	88 (48)
			624 (288)	221 (102)	35	0.66	173 (80)	61.3 (28)	n/a	n/a	n/a	250 (115)	88 (48)
			624 (288)	221 (102)	1000	0.15	39 (18)	14 (6.4)	n/a	n/a	n/a	250 (115)	88 (48)
		Tall grass	>286 <sup>i</sup> (132)	>94 (43)	15	0.95	>114 (53)	>37 (17)	n/a	n/a	n/a	>114 (53)	>37 (17)
			>286 (132)	>94 (43)	35	0.66	>79 (37)	>26 (12)	n/a	n/a	n/a	>114 (53)	>37 (17)
			>286 (132)	>94 (43)	1000	0.15	>18 (8.3)	>5.9 (2.7)	n/a	n/a	n/a	>114 (53)	>37 (17)
		Broadleaf forage plants and small insects	351 (162)	117 (54)	15	0.95	141 (66)	47 (22)	n/a	n/a	n/a	144 (65)	47 (22)
			351 (162)	117 (54)	35	0.66	97 (45)	32 (15)	n/a	n/a	n/a	144 (65)	47 (22)
			351 (162)	117 (54)	1000	0.15	22 (12)	7.4 (3.4)	n/a	n/a	n/a	144 (65)	47 (22)
		Fruits pods seeds and large insects	39 (18)	18 ( 8.4)	15	0.95	16 (7.2)	7.3 (3.4)	0.21	3.4 (1.6)	1.6 (7.0)	16 (7.2)	7.3 (3.4)
			39 (18)	18 ( 8.4)	35	0.66	18 (5.0)	5.0 (2.3)	0.15	2.5 (1.1)	1.1 (5.0)	16 (7.2)	7.3 (3.4)
			39 (18)	18 ( 8.4)	1000	0.15	2.5 (1.1)	1.1 (0.52)	0.03	0.50 (0.20)	0.20 (0.10)	16 (7.2)	7.3 (3.4)
Cotton Nemacur 3	3.0	Short grass	720	255	15	0.95	287	102	n/a	n/a	n/a	288	102
			720	255	35	0.66	200	71	n/a	n/a	n/a	288	102
			720	255	1000	0.15	45	16	n/a	n/a	n/a	288	102
		Tall grass	>330	>108	15	0.95	>132	>43	n/a	n/a	n/a	>132	>43
			>330	>108	35	0.66	>92	>30	n/a	n/a	n/a	>132	>43
			>330	>108	1000	0.15	>21	>6.8	n/a	n/a	n/a	>132	>43

**Table G3: Mammalian [Herbivore/Insectivore/Granivore (H/I/G)] Acute and Chronic RQs for Fenamiphos, Based on a Rat Acute Oral LD<sub>50</sub> of 2.38 mg/kg-bw and a Reproductive NOAEL of 2.5 ppm, for Single Applications of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./ A) <sup>a</sup>	Food Items	Maximum Residue EEC <sup>b</sup> (mg/kg)	Mean Residue EEC <sup>b</sup> (mg/kg)	Body Weight (grams) <sup>c</sup>	I <sub>bw</sub> (H/I) <sup>d</sup>	Max. Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	I <sub>bw</sub> (G) <sup>d</sup>	Max. Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>	Max Chronic RQ <sup>g</sup>	Mean Chronic RQ <sup>h</sup>
Cotton Nemacur 3	3.0	Broadleaf/ forage plants, & small insects	405	135	15	0.95	162	54	n/a	n/a	n/a	162	54
			405	135	35	0.66	112	37	n/a	n/a	n/a	162	54
			405	135	1000	0.15	26	8.5	n/a	n/a	n/a	162	54
		Fruits, pods, seeds, & large insects	45	21	15	0.95	18	8.4	0.21	4.0	1.9	18	8.4
			45	21	35	0.66	12	5.8	0.15	2.8	1.3	18	8.4
			45	21	1000	0.15	2.8	1.3	0.03	0.60	0.30	18	8.4
Table Beets (IL, IN, MI, NY, OH and PA only) Nemacur 3	3.1	Short grass	744	264	15	0.95	297	105	n/a	n/a	n/a	298	105
			744	264	35	0.66	206	73	n/a	n/a	n/a	298	105
			744	264	1,000	0.15	47	17	n/a	n/a	n/a	298	105
		Tall grass	>341	>112	15	0.95	>136	>44	n/a	n/a	n/a	>136	>45
			>341	>112	35	0.66	>95	>31	n/a	n/a	n/a	>136	>45
			>341	>112	1,000	0.15	>22	>7.0	n/a	n/a	n/a	>136	>45
		Broadleaf forage plants, and small insects	418.5	139.5	15	0.95	167.0	55.7	n/a	n/a	n/a	167.4	55.8
			418.5	139.5	35	0.66	116.1	38.7	n/a	n/a	n/a	167.4	55.8
			418.5	139.5	1,000	0.15	26.4	8.8	n/a	n/a	n/a	167.4	55.8
		Fruits, pods, seeds, and large insects	46.5	21.7	15	0.95	18.6	8.7	0.21	4.1	1.9	18.6	8.7
			46.5	21.7	35	0.66	12.9	6.0	0.15	2.9	1.4	18.6	8.7
			46.5	21.7	1,000	0.15	2.9	1.4	0.03	0.6	0.3	18.6	8.7
Strawberries Nemacur 3	4.5	Short grass	1080	383	15	0.95	431	153	n/a	n/a	n/a	432	153
			1080	383	35	0.66	300	106	n/a	n/a	n/a	432	153
			1080	383	1,000	0.15	68	24	n/a	n/a	n/a	432	153
		Tall grass	>495 <sup>i</sup>	>162	15	0.95	>198	>65	n/a	n/a	n/a	>198	>65
			>495	>162	35	0.66	>137	>45	n/a	n/a	n/a	>198	>65
			>495	>162	1,000	0.15	>31	>10	n/a	n/a	n/a	>198	>65
		Broadleaf forage plants, and small insects	>608 <sup>i</sup>	>202	15	0.95	>242	>81	n/a	n/a	n/a	>243	>81
			>608	>202	35	0.66	>168	>56	n/a	n/a	n/a	>243	>81
			>608	>202	1,000	0.15	>38	>13	n/a	n/a	n/a	>243	>81
		Fruits, pods, seeds, and large insects	68	32	15	0.95	27	13	0.21	6.0	2.8	27	13
			68	32	35	0.66	19	8.8	0.15	4.3	2.0	27	13
			68	32	1,000	0.15	4.3	2.0	0.03	0.9	0.4	27	13
Citrus (Certain FL Counties) Nemacur 3	5.0	Short grass	1200	425	15	0.95	479	170	n/a	n/a	n/a	480	170
			1200	425	35	0.66	333	118	n/a	n/a	n/a	480	170
			1200	425	1,000	0.15	76	27	n/a	n/a	n/a	480	170
		Tall grass	>550	>180	15	0.95	>220	>72	n/a	n/a	n/a	>220	>72
			>550	>180	35	0.66	>152	>50	n/a	n/a	n/a	>220	>72
			>550	>180	1,000	0.15	>35	>11	n/a	n/a	n/a	>220	>72
		Broadleaf/ forage plants, & small insects	>675	>225	15	0.95	>269	>90	n/a	n/a	n/a	>270	>90
			>675	>225	35	0.66	>187	>62	n/a	n/a	n/a	>270	>90
			>675	>225	1,000	0.15	>42	>14	n/a	n/a	n/a	>270	>90
		Fruits, pods, seeds, & large insects	75	35	15	0.95	30	14	0.21	6.6	3.1	30	14
			75	35	35	0.66	21	10	0.15	4.7	2.2	30	14
			75	35	1,000	0.15	5	2	0.03	0.9	0.4	30	14
Grapes, Kiwi Fruit (CA only), and Raspberries Nemacur 3	6.0	Short grass	1440	510	15	0.95	575	204	n/a	n/a	n/a	576	204
			1440	510	35	0.66	399	141	n/a	n/a	n/a	576	204
			1440	510	1000	0.15	91	32	n/a	n/a	n/a	576	204
		Tall grass	>660	>216	15	0.95	>263	>86	n/a	n/a	n/a	>264	>86
			>660	>216	35	0.66	>183	>60	n/a	n/a	n/a	>264	>86
			>660	>216	1,000	0.15	>42	>14	n/a	n/a	n/a	>264	>86
		Broadleaf/ forage plants, & small insects	>810	>270	15	0.95	>323	>108	n/a	n/a	n/a	>320	>108
			>810	>270	35	0.66	>225	>75	n/a	n/a	n/a	>320	>108
			>810	>270	1000	0.15	>51	>17	n/a	n/a	n/a	>320	>108
		Fruits, pods, seeds, and large insects	90	42	15	0.95	36	17	0.21	8.0	3.7	36	17
			90	42	35	0.66	25	12	0.15	5.7	2.6	36	17
			90	42	1000	0.15	5.7	3	0.03	1.1	0.50	36	17

**Table G3: Mammalian [Herbivore/Insectivore/Granivore (H/I/G)] Acute and Chronic RQs for Fenamiphos, Based on a Rat Acute Oral LD<sub>50</sub> of 2.38 mg/kg-bw and a Reproductive NOAEL of 2.5 ppm, for Single Applications of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./ A) <sup>a</sup>	Food Items	Maximum Residue EEC <sup>b</sup> (mg/kg)	Mean Residue EEC <sup>b</sup> (mg/kg)	Body Weight (grams) <sup>c</sup>	I <sub>bw</sub> (H/I) <sup>d</sup>	Max. Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	I <sub>bw</sub> (G) <sup>d</sup>	Max. Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>	Max Chronic RQ <sup>g</sup>	Mean Chronic RQ <sup>h</sup>
Tobacco Nemacur 3	6.0	Short grass	1440	510	15	0.95	575	204	n/a	n/a	n/a	576	204
			1440	510	35	0.66	399	141	n/a	n/a	n/a	576	204
			1440	510	1000	0.15	91	32	n/a	n/a	n/a	576	204
		Tall grass	>660	>216	15	0.95	>263	>86	n/a	n/a	n/a	>264	>86
			>660	>216	35	0.66	>183	>60	n/a	n/a	n/a	>264	>86
			>660	>216	1000	0.15	>42	>14	n/a	n/a	n/a	>264	>86
		Broadleaf/ forage plants, and small insects	>810	>270	15	0.95	>323	>108	n/a	n/a	n/a	>324	>108
			>810	>270	35	0.66	>225	>75	n/a	n/a	n/a	>324	>108
			>810	>270	1000	0.15	>51	>17	n/a	n/a	n/a	>324	>108
		Fruits, pods, seeds, and large insects	90	42	15	0.95	36	17	0.21	7.9	3.7	36	17
			90	42	35	0.66	25	12	0.15	5.7	2.6	36	17
			90	42	1000	0.15	6	3	0.03	1.1	0.5	36	17
Stone Fruits (peaches, cherries and nectarines)  Apple  Nemacur 3	7.5	Short grass	>1800	>638	15	0.95	>718	>254	n/a	n/a	n/a	>720	>255
			>1800	>638	35	0.66	>499	>177	n/a	n/a	n/a	>720	>255
			>1800	>638	1000	0.15	>113	>40	n/a	n/a	n/a	>720	>255
		Tall grass	>825	>270	15	0.95	>329	>108	n/a	n/a	n/a	>330	>108
			>825	>270	35	0.66	>229	>75	n/a	n/a	n/a	>330	>108
			>825	>270	1000	0.15	>52	>17	n/a	n/a	n/a	>330	>108
		Broadleaf/ forage plants, and small insects	>1012	>338	15	0.95	>404	>135	n/a	n/a	n/a	>405	>135
			>1012	>338	35	0.66	>281	>94	n/a	n/a	n/a	>405	>135
			>1012	>338	1000	0.15	>64	>21	n/a	n/a	n/a	>405	>135
		Fruits, pods, seeds, and large insects	113	53	15	0.95	45	21	0.21	10	4.6	45	21
			113	53	35	0.66	31	15	0.15	7.1	3.3	45	21
			113	53	1000	0.15	7	3	0.03	1.4	0.70	45	21
Citrus (except FL; and except Kumquat, Tangelo, and Citrus Hybrids in CA)  Nemacur 3	7.5	Short grass	>180	>63	15	9.50	>71	>25	n/a	n/a	n/a	>720	>255
			>180	>63	35	0.66	>49	>177	n/a	n/a	n/a	>720	>255
			>1800	>638	1,000	0.15	>113	>40	n/a	n/a	n/a	>720	>255
		Tall grass	>825	>270	15	0.95	>329	>108	n/a	n/a	n/a	>330	>108
			>825	>270	35	0.66	>229	>75	n/a	n/a	n/a	>330	>108
			>825	>270	1,000	0.15	>52	>17	n/a	n/a	n/a	>330	>108
		Broadleaf/ forage plants, & small insects	>1012	>338	15	0.95	>404	>135	n/a	n/a	n/a	>405	>135
			>1012	>338	35	0.66	>281	>94	n/a	n/a	n/a	>405	>135
			>1012	>338	1,000	0.15	>64	>21	n/a	n/a	n/a	>405	>135
		Fruits, pods, seeds, & large insects	112	52	15	0.95	45	21	0.21	9.9	4.6	45	21
			112	52	35	0.66	31	14	0.15	7.1	3.3	45	21
			113	53	1,000	0.15	7.1	3.3	0.03	1.4	0.7	45	21
Pineapple Nemacur 3	9.0	Short grass	>2160 <sup>i</sup>	>765	15	0.95	>862	305	n/a	n/a	n/a	>864	>306
			>2160	>765	35	0.66	>599	212	n/a	n/a	n/a	>864	>306
			>2160	>765	1,000	0.15	>136	48	n/a	n/a	n/a	>864	>306
		Tall grass	>990	>324	15	0.95	>395	129	n/a	n/a	n/a	>396	>130
			>990	>324	35	0.66	>274	90	n/a	n/a	n/a	>396	>130
			>990	>324	1,000	0.15	>62	20	n/a	n/a	n/a	>396	>130
		Broadleaf/ forage plants, and small insects	>1215	>405	15	0.95	>485	162	n/a	n/a	n/a	>486	>162
			>1215	>405	35	0.66	>337	112	n/a	n/a	n/a	>486	>162
			>1215	>405	1,000	0.15	>77	26	n/a	n/a	n/a	>486	>162
		Fruits, pods, seeds and large insects	135	63	15	0.95	54	25	0.21	12.0	5.6	54	25
			135	63	35	0.66	37	17	0.15	8.5	4.0	54	25
			135	63	1,000	0.15	8.5	4.0	0.03	1.7	0.8	54	25

**Table G3: Mammalian [Herbivore/Insectivore/Granivore (H/I/G)] Acute and Chronic RQs for Fenamiphos, Based on a Rat Acute Oral LD<sub>50</sub> of 2.38 mg/kg-bw and a Reproductive NOAEL of 2.5 ppm, for Single Applications of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./ A) <sup>a</sup>	Food Items	Maximum Residue EEC <sup>b</sup> (mg/kg)	Mean Residue EEC <sup>b</sup> (mg/kg)	Body Weight (grams) <sup>c</sup>	f <sub>bw</sub> (H/I) <sup>d</sup>	Max. Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	f <sub>bw</sub> (G) <sup>d</sup>	Max. Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>	Max Chronic RQ <sup>g</sup>	Mean Chronic RQ <sup>h</sup>
Turf  Nemacur 3	9.9	Short grass	>2376	>1450	15	0.95	>948	>579	n/a	n/a	n/a	>950	>580
			>2376	>1450	35	0.66	>659	>402	n/a	n/a	n/a	>950	>580
			>2376	>1450	1,000	0.15	>150	>91	n/a	n/a	n/a	>950	>580
		Tall grass	>1089	>664	15	0.95	>435	>265	n/a	n/a	n/a	>436	>266
			>1089	>664	35	0.66	>302	>184	n/a	n/a	n/a	>436	>266
			>1089	>664	1,000	0.15	>69	>42	n/a	n/a	n/a	>436	>266
		Broadleaf/ forage plants, and small insects	>1336	>816	15	0.95	>533	>326	n/a	n/a	n/a	>534	>326
			>1336	>816	35	0.66	>371	>226	n/a	n/a	n/a	>534	>326
			>1336	>816	1,000	0.15	>84	>51	n/a	n/a	n/a	>534	>326
		Fruits, pods, seeds, and large insects	149	91	15	0.95	59	36	0.21	13	8.0	59	36
			149	91	35	0.66	41	25	0.15	9.4	5.7	59	36
			149	91	1,000	0.15	9.4	5.7	0.03	1.9	1.1	59	36

Note: Shaded and bolded acute RQ values indicate that the acute risk, acute restricted use and acute endangered species LOCs are exceeded. Shaded but not bolded acute RQ values exceed at least the acute endangered species LOC. Shaded and bolded chronic RQ values indicated that the chronic risk LOC is exceeded.

<sup>a</sup>Maximum single application rates are from Appendix B.

<sup>b</sup>Maximum and mean residue EECs are from Appendix E.

<sup>c</sup>Risk is calculated for a representative range of avian body weights.

<sup>d</sup>Amount of food consumed per day provided in terms of fraction of the body weight consumed per day (f<sub>bw</sub> [kg of diet/kg- bw/day])

<sup>e</sup>Maximum Acute RQ = (Maximum Residue EEC [mg/kg of food item] \* f<sub>bw</sub> [kg of diet/kg-bw/day]) ÷ (LD<sub>50</sub> [mg/kg-bw/day])

<sup>f</sup>Mean Acute RQ = (Mean Residue EEC [mg/kg of food item] \* f<sub>bw</sub> [kg of diet/kg-bw/day]) ÷ (LD<sub>50</sub> [mg/kg-bw/day])

<sup>g</sup>Maximum Chronic RQ = (Maximum Residue EEC [ppm]) ÷ (NOAEL [ppm]); note 1 ppm = 1 mg/kg

<sup>h</sup>Mean Chronic RQ = (Mean Residue EEC [ppm]) ÷ (NOAEL [ppm]); note 1 ppm = 1mg/kg

<sup>i</sup>> symbol means tall grass, short grass, and forage plants exceeded Hoerger-Kenaga values at application rates greater than 2.5, 6.0, and 4.0 lb a.i./A, respectively.



**Table G4: Mammalian [(Herbivore/Insectivore/Granivore (H/I/G))] Acute RQs for Fenamiphos Sulfone, based on a Rat Acute Oral LD<sub>50</sub> of 2.6 mg/kg for Fenamiphos Sulfone, from a Single Application of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./A)	Food Items	Maximum Residue EEC (mg/kg) <sup>a</sup>	Mean Residue EEC (mg/kg) <sup>b</sup>	Body Weight (grams) <sup>c</sup>	Fraction Body Weight Consumed (H/I) <sup>d</sup>	Maximum Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	Fraction Body Weight Consumed (G) <sup>d</sup>	Maximum Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>
Asparagus (CT, DE, ME, MA, NH, NJ, NY, PA, and RI only)  Eggplant  Nemacur 3	2.0	Short grass	17	6.0	0.0	0.95	<b>6.1</b>	<b>2.2</b>	n/a	n/a	n/a
			17	6.0	35	0.66	<b>4.3</b>	<b>1.5</b>	n/a	n/a	n/a
			17	6.0	1,000	0.15	<b>1.0</b>	0.3	n/a	n/a	n/a
		Tall grass	7.7	2.5	15	0.95	<b>2.8</b>	<b>0.9</b>	n/a	n/a	n/a
			7.7	2.5	35	0.66	<b>2.0</b>	<b>0.6</b>	n/a	n/a	n/a
			7.7	2.5	1,000	0.15	0.4	0.1	n/a	n/a	n/a
		Broadleaf/ forage plants, and small insects	9.5	3.2	15	0.95	<b>3.5</b>	<b>1.2</b>	n/a	n/a	n/a
			9.5	3.2	35	0.66	<b>2.4</b>	<b>0.8</b>	n/a	n/a	n/a
			9.5	3.2	1,000	0.15	0.5	0.2	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	1.1	0.5	15	0.95	0.4	0.2	0.21	0.09	0.04
			1.1	0.5	35	0.66	0.3	0.1	0.15	0.06	0.03
			1.1	0.5	1,000	0.15	0.1	0.0	0.03	0.01	0.01
Peanuts Nemacur 3	2.5 (1.2)	Short grass	22 (10)	7.7 (3.6)	15	0.95	<b>8.0 (4.0)</b>	<b>2.8 (1.4)</b>	n/a	n/a	n/a
			22 (10)	7.7 (3.6)	35	0.66	<b>5.5 (2.8)</b>	<b>2.0 (1.0)</b>	n/a	n/a	n/a
			22 (10)	7.7 (3.6)	1,000	0.15	<b>1.3 (0.6)</b>	0.4 (0.23)	n/a	n/a	n/a
		Tall grass	10 (4.6)	3.3 (1.5)	15	0.95	<b>3.7 (1.8)</b>	<b>1.2 (0.60)</b>	n/a	n/a	n/a
			10 (4.6)	3.3 (1.5)	35	0.66	<b>2.6 (1.3)</b>	<b>0.8 (0.42)</b>	n/a	n/a	n/a
			10 (4.6)	3.3 (1.5)	1,000	0.15	<b>0.6 (0.29)</b>	0.2 (0.09)	n/a	n/a	n/a
		Broadleaf/ forage plants, and small insects	12 (5.7)	4.1 (1.9)	15	0.95	<b>4.5 (2.3)</b>	<b>1.5 (0.76)</b>	n/a	n/a	n/a
			12 (5.7)	4.1 (1.9)	35	0.66	<b>3.1 (1.6)</b>	<b>1.0 (0.53)</b>	n/a	n/a	n/a
			12 (5.7)	4.1 (1.9)	1,000	0.15	<b>0.7 (0.36)</b>	0.2 (0.12)	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	1.4 (0.6)	0.6 (0.3)	15	0.95	0.5 (0.24)	0.2 (0.12)	0.21	0.11 (0.05)	0.05 (0.03)
			1.4 (0.6)	0.6 (0.3)	35	0.66	0.4 (0.17)	0.2 (0.08)	0.15	0.08 (0.04)	0.03 (0.02)
			1.4 (0.6)	0.6 (0.3)	1,000	0.15	0.1 (0.04)	0.04 (0.02)	0.03	0.02 ( $<0.01$ )	0.01 ( $<0.01$ )
Cotton Nemacur 3	3.0	Short grass	25	8.9	15	0.95	<b>9.2</b>	<b>3.3</b>	n/a	n/a	n/a
			25	8.9	35	0.66	<b>6.4</b>	<b>2.3</b>	n/a	n/a	n/a
			25	8.9	1,000	0.15	<b>1.5</b>	0.5	n/a	n/a	n/a
		Tall grass	$>12^g$	$>3.8$	15	0.95	$>4.2$	$>1.4$	n/a	n/a	n/a
			$>12$	$>3.8$	35	0.66	$>3.0$	$>1.0$	n/a	n/a	n/a
			$>12$	$>3.8$	1,000	0.15	$>0.7$	$>0.2$	n/a	n/a	n/a
		Broadleaf/ forage plants, & small insects	14	4.7	15	0.95	<b>5.2</b>	<b>1.7</b>	n/a	n/a	n/a
			14	4.7	35	0.66	<b>3.6</b>	<b>1.2</b>	n/a	n/a	n/a
			14	4.7	1,000	0.15	<b>0.8</b>	0.3	n/a	n/a	n/a
		Fruits, pods, seeds, & large insects	1.6	0.7	15	0.95	<b>0.6</b>	0.3	0.21	0.13	0.06
			1.6	0.7	35	0.66	0.4	0.2	0.15	0.09	0.04
			1.6	0.7	1,000	0.15	0.1	0.0	0.03	0.02	0.01
Table Beets (IL, IN, MI, NY, OH and PA only)  Nemacur 3	3.1	Short grass	26	9.2	15	0.95	<b>9.5</b>	<b>3.4</b>	n/a	n/a	n/a
			26	9.2	35	0.66	<b>6.6</b>	<b>2.3</b>	n/a	n/a	n/a
			26	9.2	1,000	0.15	<b>1.5</b>	0.5	n/a	n/a	n/a
		Tall grass	$>12$	$>3.9$	15	0.95	$>4.9$	$>1.4$	n/a	n/a	n/a
			$>12$	$>3.9$	35	0.66	$>3.0$	$>1.0$	n/a	n/a	n/a
			$>12$	$>3.9$	1,000	0.15	$>0.7$	$>0.2$	n/a	n/a	n/a

**Table G4: Mammalian [(Herbivore/Insectivore/Granivore (H/I/G))] Acute RQs for Fenamiphos Sulfone, based on a Rat Acute Oral LD<sub>50</sub> of 2.6 mg/kg for Fenamiphos Sulfone, from a Single Application of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./A)	Food Items	Maximum Residue EEC (mg/kg) <sup>a</sup>	Mean Residue EEC (mg/kg) <sup>b</sup>	Body Weight (grams) <sup>c</sup>	Fraction Body Weight Consumed (H/I) <sup>d</sup>	Maximum Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	Fraction Body Weight Consumed (G) <sup>d</sup>	Maximum Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>
Strawberries  Nemacur 3	4.5	Broadleaf/ forage plants, and small insects	15	4.9	15	0.95	6.0	1.8	n/a	n/a	n/a
			15	4.9	35	0.66	3.7	1.2	n/a	n/a	n/a
			15	4.9	1,000	0.15	0.8	0.3	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	1.6	0.8	15	0.95	0.7	0.3	0.21	0.13	0.06
			1.6	0.8	35	0.66	0.4	0.2	0.15	0.09	0.05
			1.6	0.8	1,000	0.15	0.1	0.0	0.03	0.02	0.01
	4.5	Short grass	38	13	15	0.95	13.8	4.9	n/a	n/a	n/a
			38	13	35	0.66	9.6	3.4	n/a	n/a	n/a
			38	13	1,000	0.15	2.2	0.8	n/a	n/a	n/a
		Tall grass	>17	>5.7	15	0.95	6.2	2.1	n/a	n/a	n/a
			>17	>5.7	35	0.66	4.3	1.4	n/a	n/a	n/a
			>17	>5.7	1,000	0.15	1.0	0.3	n/a	n/a	n/a
		Broadleaf/ forage plants, and small insects	>21 <sup>g</sup>	>7.1	15	0.95	7.7	2.6	n/a	n/a	n/a
			>21	>7.1	35	0.66	5.3	1.8	n/a	n/a	n/a
			>21	>7.1	1,000	0.15	1.2	0.4	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	2.4	1.1	15	0.95	0.9	0.4	0.21	0.19	0.09
			2.4	1.1	35	0.66	0.6	0.3	0.15	0.14	0.06
			2.4	1.1	1,000	0.15	0.1	0.1	0.03	0.01	0.01
Citrus (Certain FL Counties)  Nemacur 3	5.0	Short grass	42	15	15	0.95	15	5.4	n/a	n/a	n/a
			42	15	35	0.66	11	3.8	n/a	n/a	n/a
			42	15	1,000	0.15	2.4	0.9	n/a	n/a	n/a
		Tall grass	19	6.3	15	0.95	7.0	2.3	n/a	n/a	n/a
			19	6.3	35	0.66	4.9	1.6	n/a	n/a	n/a
			19	6.3	1,000	0.15	1.1	0.4	n/a	n/a	n/a
		Broadleaf/ forage plants, & small insects	24	7.9	15	0.95	8.6	2.9	n/a	n/a	n/a
			24	7.9	35	0.66	6.0	2.0	n/a	n/a	n/a
			24	7.9	1,000	0.15	1.4	0.5	n/a	n/a	n/a
		Fruits, pods, seeds, & large insects	2.6	1.2	15	0.95	1.0	0.4	0.21	0.21	0.10
			2.6	1.2	35	0.66	0.7	0.3	0.15	0.15	0.07
			2.6	1.2	1,000	0.15	0.2	0.1	0.03	0.03	0.01
Grapes, Tobacco, Raspberry and Kiwi Fruit (CA only)  Nemacur 3	6.0	Short grass	50	18	15	0.95	18	6.5	n/a	n/a	n/a
			50	18	35	0.66	13	4.5	n/a	n/a	n/a
			50	18	1,000	0.15	2.9	1.0	n/a	n/a	n/a
		Tall grass	23	7.6	15	0.95	8.4	2.8	n/a	n/a	n/a
			23	7.6	35	0.66	5.9	1.9	n/a	n/a	n/a
			23	7.6	1,000	0.15	1.3	0.4	n/a	n/a	n/a
		Broadleaf/ forage plants, & small insects	28	9.5	15	0.95	10.4	3.5	n/a	n/a	n/a
			28	9.5	35	0.66	7.2	2.4	n/a	n/a	n/a
			28	9.5	1,000	0.15	1.6	0.5	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	3.2	1.5	15	0.95	1.2	0.5	0.21	0.26	0.12
			3.2	1.5	35	0.66	0.8	0.4	0.15	0.18	0.09
			3.2	1.5	1,000	0.15	0.2	0.1	0.03	0.04	0.02
Citrus (except FL; and except Kumquat, Tangelo, and Citrus Hybrids in CA) Nemacur 3	7.5	Short grass	63	22	15	0.95	23	8.2	n/a	n/a	n/a
			63	22	35	0.66	16	5.7	n/a	n/a	n/a
			63	22	1,000	0.15	3.6	1.3	n/a	n/a	n/a
		Tall grass	29	9.5	15	0.95	11	3.5	n/a	n/a	n/a
			29	9.5	35	0.66	7.3	2.4	n/a	n/a	n/a
			29	9.5	1,000	0.15	1.7	0.5	n/a	n/a	n/a
		Broadleaf/ forage plants, & small insects	35	12	15	0.95	12.9	4.3	n/a	n/a	n/a
			35	12	35	0.66	9.0	3.0	n/a	n/a	n/a
			35	12	1,000	0.15	2.0	0.7	n/a	n/a	n/a
		Fruits, pods, seeds, & large insects	3.9	1.8	15	0.95	1.4	0.7	0.21	0.32	0.15
			3.9	1.8	35	0.66	1.0	0.5	0.15	0.23	0.10
			3.9	1.8	1,000	0.15	0.2	0.1	0.03	0.05	0.02

**Table G4: Mammalian [(Herbivore/Insectivore/Granivore (H/I/G))] Acute RQs for Fenamiphos Sulfone, based on a Rat Acute Oral LD<sub>50</sub> of 2.6 mg/kg for Fenamiphos Sulfone, from a Single Application of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./A)	Food Items	Maximum Residue EEC (mg/kg) <sup>a</sup>	Mean Residue EEC (mg/kg) <sup>b</sup>	Body Weight (grams) <sup>c</sup>	Fraction Body Weight Consumed (H/I) <sup>d</sup>	Maximum Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	Fraction Body Weight Consumed (G) <sup>d</sup>	Maximum Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>
Stone Fruits (peaches, cherries and nectarines)  Apple  Nemacur 3	7.5	Short grass	63	22	15	0.95	23.0	8.2	n/a	n/a	n/a
			63	22	35	0.66	16.0	5.7	n/a	n/a	n/a
			63	22	1,000	0.15	3.6	1.3	n/a	n/a	n/a
		Tall grass	29	9	15	0.95	10.6	3.5	n/a	n/a	n/a
			29	9	35	0.66	7.3	2.4	n/a	n/a	n/a
			29	9	1,000	0.15	1.7	0.5	n/a	n/a	n/a
		Broadleaf/ forage plants, and small insects	35	12	15	0.95	12.9	4.3	n/a	n/a	n/a
			35	12	35	0.66	9.0	3.0	n/a	n/a	n/a
			35	12	1,000	0.15	2.0	0.7	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	3.9	1.8	15	0.95	1.4	0.7	0.21	0.32	0.15
			3.9	1.8	35	0.66	1.0	0.5	0.15	0.23	0.10
			3.9	1.8	1,000	0.15	0.2	0.1	0.03	0.05	0.02
Pineapple Nemacur 3	9.0	Short grass	76	27	15	0.95	28	9.8	n/a	n/a	n/a
			76	27	35	0.66	19	6.8	n/a	n/a	n/a
			76	27	1,000	0.15	4.4	1.5	n/a	n/a	n/a
		Tall grass	35	11	15	0.95	13	4.1	n/a	n/a	n/a
			35	11	35	0.66	8.8	2.9	n/a	n/a	n/a
			35	11	1,000	0.15	2	0.7	n/a	n/a	n/a
		Broadleaf/ forage plants, and small insects	43	14	15	0.95	16	5.2	n/a	n/a	n/a
			43	14	35	0.66	11	3.6	n/a	n/a	n/a
			43	14	1,000	0.15	2.5	0.8	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	4.7	2.2	15	0.95	1.7	0.8	0.21	0.38	0.18
			4.7	2.2	35	0.66	1.2	0.6	0.15	0.27	0.13
			4.7	2.2	1,000	0.15	0.3	0.1	0.03	0.05	0.03

**Table G4: Mammalian [(Herbivore/Insectivore/Granivore (H/I/G))] Acute RQs for Fenamiphos Sulfone, based on a Rat Acute Oral LD<sub>50</sub> of 2.6 mg/kg for Fenamiphos Sulfone, from a Single Application of Nemacur 3.**

Crop/ Formulation	Max Single Appl. Rate (lb a.i./A)	Food Items	Maximum Residue EEC (mg/kg) <sup>a</sup>	Mean Residue EEC (mg/kg) <sup>b</sup>	Body Weight (grams) <sup>c</sup>	Fraction Body Weight Consumed (H/I) <sup>d</sup>	Maximum Acute RQ (H/I) <sup>e</sup>	Mean Acute RQ (H/I) <sup>f</sup>	Fraction Body Weight Consumed (G) <sup>d</sup>	Maximum Acute RQ (G) <sup>e</sup>	Mean Acute RQ (G) <sup>f</sup>
Turf Nemacur 3	9.9	Short grass	83	51	15	0.95	<b>32</b>	<b>20</b>	n/a	n/a	n/a
			83	51	35	0.66	<b>23</b>	<b>14</b>	n/a	n/a	n/a
			83	51	1,000	0.15	<b>5.2</b>	<b>3.2</b>	n/a	n/a	n/a
		Tall grass	38	23	15	0.95	<b>15</b>	<b>9.2</b>	n/a	n/a	n/a
			38	23	35	0.66	<b>10</b>	<b>6.4</b>	n/a	n/a	n/a
			38	23	1,000	0.15	<b>2.4</b>	<b>1.4</b>	n/a	n/a	n/a
		Broadleaf/ forage plants, and small insects	47	28	15	0.95	<b>19</b>	<b>11</b>	n/a	n/a	n/a
			47	28	35	0.66	<b>13</b>	<b>7.8</b>	n/a	n/a	n/a
			47	28	1,000	0.15	<b>3</b>	<b>1.8</b>	n/a	n/a	n/a
		Fruits, pods, seeds, and large insects	5.2	3.2	15	0.95	<b>2.1</b>	<b>1.3</b>	0.21	0.46	0.28
			5.2	3.2	35	0.66	<b>1.4</b>	<b>0.9</b>	0.15	0.33	0.20
			5.2	3.2	1,000	0.15	<b>0.33</b>	<b>0.2</b>	0.03	0.06	0.04

Note: Shaded and bolded acute RQ values indicate that the acute risk, acute restricted use and acute endangered species LOCs are exceeded. Shaded but not bolded acute RQ values exceed at least the acute endangered species LOC.

<sup>a</sup>Maximum residue EEC for fenamiphos sulfone = Maximum residue EEC for fenamiphos from Table G3 times 0.035; assumes 3.5% of applied fenamiphos is present as fenamiphos sulfone.

<sup>b</sup>Mean residue EECs for fenamiphos sulfone = Mean residue EEC for fenamiphos from Table G3 times 0.035; assumes 3.5% of applied fenamiphos is present as fenamiphos sulfone.

<sup>c</sup>Risk is calculated for a representative range of avian body weights.

<sup>d</sup>Amount of food consumed per day provided in terms of fraction of the body weight consumed per day.

<sup>e</sup>Maximum Acute RQ = (Maximum Residue EEC [ppm]) ÷ (LC<sub>50</sub> [ppm])

<sup>f</sup>Mean Acute RQ = (Mean Residue EEC [ppm]) ÷ (LC<sub>50</sub> [ppm])

<sup>g</sup>> symbol means tall grass, short grass, and forage plants exceeded Hoerger-Kenaga values at application rates greater than 2.5, 6.0, and 4.0 lb a.i./A, respectively.

**Table G5. Mammalian Acute RQs, Based on a Laboratory Rat LD<sub>50</sub> of 2.3 mg a.i./kg-bw/day, for Single Applications of Fenamiphos Granular Products.**

Site/Application Method Band Width (feet) Crop Row Spacing (ft)	% a.i.	Application Rate (oz of product/1,000 ft of row)	Applicatio n Rate <sup>a</sup> (lb a.i./A)	Application Rate <sup>b</sup> (mg a.i./ft <sup>2</sup> )	% of Pesticide Left on the Soil <sup>c</sup>	Exposed <sup>d</sup> (mg a.i./ft <sup>2</sup> )	Body Weight (grams)	Acute RQ <sup>e,f</sup>
Cotton/At planting 1 3	15	12	1.6	51	15	7.7	15 35 1000	214 92 3
Strawberries/Prior to planting 1.5 2	15	22	4.5	62.4	15	9.4	15 35 1000	262 112 4
Eggplant & non-bell peppers/At planting 1 3	15	14.7	2.0	62.5	15	9.4	15 35 1000	263 113 4
Okra/At planting 1.25 3.33	15	18.4	2.3	62.6	15	9.4	15 35 1000	263 113 4
Bok choy, cabbage, & brussel sprouts/At planting 1.25 1.67	15	18.4	4.5	62.6	15	9.4	15 35 1000	263 113 4
Bananas & plantains/ Established plants Not applicable Not applicable	15	Not applicable	6.8	70.8	1	0.7	15 35 1000	20 9 0.3
Garlic/At planting 0.1 1.67	15	18.4	4.5	782	1	7.8	15 35 1000	219 94 3
Iris, lily & narcissus bulbs/ Established plants 1 3.5	10	128	10	363	15	54	15 35 1000	1,525 653 23
Leatherleaf fern, anthurium & nursery stock/Established plants Not applicable Not applicable	10	Not applicable	10	104	100	104	15 35 1000	2,917 1,250 44
Non-bearing strawberries & nursery stock/Pretransplant 1 2	15	17	3.5	72.3	15	10.8	15 35 1000	304 130 5
Peanuts/At planting 1 3	15	18.7	2.5	79.5	15	11.9	15 35 1000	334 143 5
Pineapple/Before planting Not applicable Not applicable	15	Not applicable	9.0	93.7	15	14.1	15 35 1000	394 169 6
Turf/Established plants Not applicable Not applicable	10	Not applicable	10	104	100	104	20 180 1000	2,917 1,250 44

Note: Shaded acute RQ cells indicate that the acute risk, acute restricted use and acute endangered species LOCs are exceeded.

<sup>a</sup>Application rates in lbs a.i./A are from Appendix B.

<sup>b</sup>Application Rate (mg a.i./ft<sup>2</sup> within band) = [Application Rate (lb a.i./A) \* 453,590 mg/lb] ÷ [(43,560 (ft<sup>2</sup>/A) ÷ Crop Row Spacing (ft)) \* Band Width (ft)]  
Application Rate for Broadcast (mg a.i./ft<sup>2</sup>) = [Application Rate (lb a.i./A) \* 453,590 mg/lb] ÷ 43,560 (ft<sup>2</sup>/A)

<sup>c</sup>Incorporation efficiency: Banded (covered with specified amount of soil), in-furrow, drill or shanked-in = 99%

Side-dress, banded or broadcast (all mixed or lightly incorporated with soil) = 85%

Side-dress, banded, broadcast, aerial broadcast (all unincorporated) = 0%

<sup>d</sup>Exposed (mg a.i./ft<sup>2</sup> within the band) = Application Rate (mg a.i./ft<sup>2</sup> within band) \* (1 - Incorporation efficiency)

Exposed for Broadcast (mg a.i./ft<sup>2</sup>) = Application Rate for Broadcast (mg a.i./ft<sup>2</sup>) \* (1 - Incorporation efficiency)

<sup>e</sup>RQ = Exposed (mg a.i./ft<sup>2</sup>) ÷ [LD<sub>50</sub> (mg a.i./kg-bw) \* Body weight (grams) \* 1 kg/1000 grams]

<sup>f</sup>RQ values exceeding levels of concern are shaded.

<sup>g</sup>Exposed granules (no./ft<sup>2</sup>) = Exposed substance (mg a.i./ft<sup>2</sup>) ÷ (x lbs a.i./1 lb of product \* 0.087 mg/granule) from Balcomb, et al. (1984).





## APPENDIX H: Back calculation of Application Rates Which Meet Terrestrial LOCs

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**Table H1. Back Calculated Emulsifiable Application Rates Which Meet Avian LOCs for Residue Levels on Food**

Food Item	Endangered Species (LOC = 0.1)		Acute Restricted Use (LOC = 0.2)		Acute Risk (LOC = 0.5)		Chronic Risk (LOC = 1)	
	Maximum <sup>a</sup> (lbs a.i./A)	Mean <sup>a</sup> (lbs a.i./A)	Maximum <sup>a</sup> (lbs a.i./A)	Mean <sup>a</sup> (lbs a.i./A)	Maximum <sup>a</sup> (lbs a.i./A)	Mean <sup>a</sup> (lbs a.i./A)	Maximum <sup>b</sup> (lbs a.i./A)	Mean <sup>b</sup> (lbs a.i./A)
Short grass	0.016	0.045	0.032	0.089	0.079	0.22	0.008	0.024
Tall grass	0.035	0.106	0.069	0.211	0.17	0.53	0.018	0.056
Broadleaf/forage plants, and small insects	0.028	0.084	0.056	0.169	0.14	0.42	0.015	0.044
Fruits, pods, seeds and large insects	0.25	0.54	0.51	1.1	1.3	2.7	0.13	0.29

<sup>a</sup>Back calculation equations for lbs a.i./A which when applied would be equal to the LOC:

$$\text{Maximum } x \frac{(\text{lbs a.i.})}{1 (A)} = \frac{(\text{LOC (unitless)} \times \text{LC}_{50} (\text{mg / kg of diet}))}{\left( \frac{\text{Maximum HK EEC}_i (\text{mg / kg of food item})}{1 (\text{lb a.i.}) / 1 (A)} \right)}$$

$$\text{Mean } x \frac{(\text{lbs a.i.})}{1 (A)} = \frac{(\text{LOC (unitless)} \times \text{LC}_{50} (\text{mg / kg of diet}))}{\left( \frac{\text{Mean HK EEC}_i (\text{mg / kg of food item})}{1 (\text{lb a.i.}) / 1 (A)} \right)}$$

where:

HK EEC<sub>i</sub> is the Hoerger-Kenaga Residue Value for food item i (Table 4);

LC<sub>50</sub> value is from acute oral avian study on Table 11;

Note 1 ppm = 1 mg/kg.

<sup>b</sup>Back calculations for applications below chronic LOCs are calculated using the same equations provided in footnote a above except that the LC<sub>50</sub> values are replaced by the avian chronic NOAEL (ppm) from Table 11.

**Table H2. Back Calculated Emulsifiable Application Rates Which Meet Mammalian LOCs for Residue Levels on Food**

Residues	Body wt grams	$f_{bw}$ <sup>a</sup>	Endangered Species LOC = 0.1		Acute Restricted Use LOC = 0.2		Acute Risk LOC = 0.5		Chronic Risk LOC = 1	
			Maximum <sup>b</sup> (lbs a.i./A)	Mean <sup>b</sup> (lbs a.i./A)	Maximum <sup>b</sup> (lbs a.i./A)	Mean <sup>b</sup> (lbs a.i./A)	Maximum <sup>b</sup> (lbs a.i./A)	Mean <sup>b</sup> (lbs a.i./A)	Maximum <sup>c</sup> (lbs a.i./A)	Mean <sup>c</sup> (lbs a.i./A)
Short grass	15	0.95	0.001	0.003	0.002	0.006	0.005	0.015	0.001	0.004
	35	0.66	0.002	0.004	0.003	0.008	0.008	0.021	0.002	0.005
	1000	0.15	0.007	0.019	0.013	0.037	0.033	0.093	0.008	0.024
Tall grass	15	0.95	0.002	0.007	0.005	0.014	0.011	0.035	0.003	0.009
	35	0.66	0.003	0.01	0.007	0.02	0.016	0.05	0.004	0.013
	1000	0.15	0.014	0.044	0.029	0.088	0.072	0.22	0.018	0.056
Broadleaf/forage plants, and small insects	15	0.95	0.002	0.006	0.004	0.011	0.009	0.028	0.002	0.007
	35	0.66	0.003	0.008	0.005	0.016	0.013	0.04	0.003	0.01
	1000	0.15	0.012	0.035	0.024	0.071	0.059	0.176	0.015	0.044
Fruits, pods, seeds and large insects	15	0.95	0.017	0.036	0.033	0.072	0.084	0.18	0.021	0.045
	35	0.66	0.024	0.052	0.048	0.103	0.12	0.26	0.03	0.065
	1000	0.15	0.11	0.23	0.21	0.45	0.53	1.1	0.13	0.29

<sup>a</sup>  $f_{bw}$  = Amount of food consumed per day provided in terms of fraction of the body weight consumed (kg of diet/kg-bw/day).

<sup>b</sup> Back calculation equations for lbs a.i./A which when applied would be equal to the LOC:

$$\text{Maximum } x \frac{(\text{lbs a.i.})}{1 (A)} = \frac{(\text{LOC (unitless)} \times \text{LD}_{50} (\text{mg / kg - bw / day}))}{\left( \frac{\text{Maximum HK EEC}_i (\text{mg / kg of food item})}{1 (\text{lb a.i.}) / 1 (A)} \times f_{bw} \frac{(\text{kg of diet})}{(\text{kg - bw})} \right)}$$

$$\text{Mean } x \frac{(\text{lbs a.i.})}{1 (A)} = \frac{(\text{LOC (unitless)} \times \text{LD}_{50} (\text{mg / kg - bw / day}))}{\left( \frac{\text{Mean HK EEC}_i (\text{mg / kg of food item})}{1 (\text{lb a.i.}) / 1 (A)} \times f_{bw} \frac{(\text{kg of diet})}{(\text{kg - bw})} \right)}$$

where:

HK<sub>EECS</sub> is the Hoerger-Kenaga Residue Value for food item i (Table 4);

LD<sub>50</sub> value is from acute dietary mammalian study on Table 11;

Note 1 ppm = 1 mg/kg.

<sup>c</sup> Back calculations for applications below chronic LOCs are calculated using the same equations provided in footnote b above except that the LD<sub>50</sub> values are replaced by the mammalian reproductive NOAEL (ppm) from Table 11.

**Table H3. Back Calculated Granular Application Rates That Meet Avian LOCs.**

Application	Band width (ft)	Row Spacing (ft)	Body wt (g)	f <sub>efficiency</sub> <sup>a</sup>	Endangered Species LOC = 0.1		Acute Restricted LOC = 0.2		Acute Risk LOC = 0.5	
					(lbs a.i./A) <sup>c</sup>	(mg a.i./ft <sup>2</sup> ) <sup>b</sup>	(lbs a.i./A) <sup>c</sup>	(mg a.i./ft <sup>2</sup> ) <sup>b</sup>	(lbs a.i./A) <sup>c</sup>	(mg a.i./ft <sup>2</sup> ) <sup>b</sup>
Band/Incorporated	1	1.67	20	0.85	0.0012	0.021	0.0025	0.04	0.0061	0.11
			180	0.85	0.0110	0.19	0.022	0.38	0.055	0.96
			1000	0.85	0.061	1.1	0.12	2.1	0.31	5.3
	1	2	20	0.85	0.0010	0.021	0.0020	0.04	0.0051	0.11
			180	0.85	0.0092	0.19	0.018	0.38	0.046	0.96
			1000	0.85	0.051	1.1	0.10	2.1	0.26	5.3
	1	3	20	0.85	0.0007	0.021	0.0014	0.04	0.0034	0.11
			180	0.85	0.0061	0.19	0.012	0.38	0.031	0.96
			1000	0.85	0.034	1.1	0.07	2.1	0.17	5.3
	1	3.5	20	0.85	0.0006	0.021	0.0012	0.04	0.0029	0.11
			180	0.85	0.0053	0.19	0.011	0.38	0.026	0.96
			1000	0.85	0.029	1.1	0.06	2.1	0.15	5.3
	1.25	3.33	20	0.85	0.0008	0.021	0.0015	0.04	0.0038	0.11
			180	0.85	0.0069	0.19	0.014	0.38	0.035	0.96
			1000	0.85	0.038	1.1	0.08	2.1	0.19	5.3
	1.25	1.67	20	0.85	0.0015	0.021	0.0031	0.04	0.0077	0.11
			180	0.85	0.0138	0.19	0.028	0.38	0.069	0.96
			1000	0.85	0.077	1.1	0.15	2.1	0.38	5.3
	1.5	2	20	0.85	0.0015	0.021	0.0031	0.04	0.0077	0.11
			180	0.85	0.0138	0.19	0.028	0.38	0.069	0.96
			1000	0.85	0.077	1.1	0.15	2.1	0.38	5.3
In-furrow/ Incorporated	NA	NA	20	0.99	0.031	0.32	0.061	0.64	0.15	1.6
			180	0.99	0.28	2.9	0.55	5.8	1.4	14
			1000	0.99	1.5	16	3.1	32	7.7	80
Broadcast/ Unincorporated	NA	NA	20	0	0.00031	0.0032	0.00061	0.0064	0.0015	0.016
			180	0	0.0028	0.029	0.0055	0.058	0.014	0.14
			1000	0	0.015	0.16	0.031	0.32	0.077	0.80

<sup>a</sup>Incorporation efficiency factor is the fraction of granular-sized particles that are incorporated into the soil for a given application method: which is 0 for broadcast, unincorporated; 0.85 for banded, incorporated; and 0.99 for in-furrow, incorporated.

<sup>b</sup>Back calculation equations for mg a.i./ft<sup>2</sup> which when applied will meet the LOC. BW is body weight.

When applied in bands:

$$y \frac{(\text{mg a.i.})}{1 (\text{ft}^2 \text{ within band})} = \frac{\text{LOC}/(\text{ft}^2) \times \text{LD}_{50} (\text{mg} / \text{kg} - \text{bw} / \text{day}) \times \text{BW} (\text{grams}) \times \frac{1 (\text{kg})}{1,000 (\text{kg})}}{(1 - f_{\text{efficiency}})}$$

When applied as broadcast: the same equation for in bands is used except the units are as mg a.i./ft<sup>2</sup>.

<sup>c</sup>Calculation of lbs a.i./A.

When applied in bands:

$$x \frac{(\text{lbs a.i.})}{1 (\text{A})} = \frac{y \frac{(\text{mg a.i.})}{1 (\text{ft}^2 \text{ within band})} \times \frac{1 (\text{lb})}{453,590 (\text{mg})}}{\left( \frac{43,560 (\text{ft}^2)}{1 (\text{A})} \times z (\text{bandwidth in ft}) \right) / i (\text{row spacing in ft})}$$

When broadcast:

$$x \frac{(\text{lbs a.i.})}{1 (\text{A})} = y \frac{(\text{mg a.i.})}{1 (\text{ft}^2 \text{ within band})} \times \frac{1 (\text{lb})}{453,590 (\text{mg})} \times \frac{43,560 (\text{ft}^2)}{1 (\text{A})}$$

**Table H4. Back Calculated Granular Application Rates That Meet Mammalian LOCs.**

Granular	Band width (ft)	Row Spacing (ft)	Body wt (g)	f <sub>efficiency</sub> <sup>a</sup>	Endangered Species LOC = 0.1		Acute Restricted LOC = 0.2		Acute Risk LOC = 1	
					(lbs a.i./A) <sup>c</sup>	(mg a.i./ft <sup>2</sup> ) <sup>b</sup>	(lbs a.i./A) <sup>c</sup>	(mg a.i./ft <sup>2</sup> ) <sup>b</sup>	(lbs a.i./A) <sup>c</sup>	(mg a.i./ft <sup>2</sup> ) <sup>b</sup>
Band/Incorporated	1	1.67	15	0.85	0.0013	0.023	0.0026	0.05	0.0066	0.12
			35	0.85	0.0031	0.05	0.0062	0.11	0.015	0.27
			1000	0.85	0.088	1.5	0.18	3.1	0.44	7.7
	1	2	20	0.85	0.0015	0.031	0.0029	0.06	0.0074	0.15
			180	0.85	0.0133	0.28	0.027	0.55	0.066	1.4
			1000	0.85	0.074	1.5	0.15	3.1	0.37	7.7
	1	3	20	0.85	0.0010	0.031	0.0020	0.06	0.0049	0.15
			180	0.85	0.0088	0.28	0.018	0.55	0.044	1.4
			1000	0.85	0.049	1.5	0.10	3.1	0.25	7.7
	1	3.5	20	0.85	0.0008	0.031	0.0017	0.06	0.0042	0.15
			180	0.85	0.0076	0.28	0.015	0.55	0.038	1.4
			1000	0.85	0.042	1.5	0.08	3.1	0.21	7.7
	1.25	3.33	20	0.85	0.0011	0.031	0.0022	0.06	0.0055	0.15
			180	0.85	0.0099	0.28	0.020	0.55	0.050	1.38
			1000	0.85	0.055	1.5	0.11	3.1	0.28	7.7
	1.25	1.67	20	0.85	0.0022	0.031	0.0044	0.06	0.011	0.15
			180	0.85	0.0198	0.28	0.040	0.55	0.099	1.4
			1000	0.85	0.110	1.5	0.22	3.1	0.55	7.7
	1.5	2	20	0.85	0.0022	0.031	0.0044	0.06	0.0110	0.15
			180	0.85	0.0199	0.28	0.040	0.55	0.099	1.4
			1000	0.85	0.110	1.5	0.22	3.1	0.55	7.7
In-furrow/ Incorporated	NA	NA	20	0.99	0.044	0.46	0.088	0.92	0.22	2.3
			180	0.99	0.40	4.1	0.80	8.3	2.0	21
			1000	0.99	2.2	23	4.4	46	11.0	115
Broadcast/ Unincorporated	NA	NA	20	0	0.00044	0.0046	0.00088	0.0092	0.0022	0.023
			180	0	0.0040	0.041	0.0080	0.083	0.020	0.21
			1000	0	0.022	0.23	0.044	0.46	0.110	1.15

<sup>a</sup>Incorporation efficiency factor is the fraction of granular-sized particles that are incorporated into the soil for a given application method: which is 0 for broadcast, unincorporated; 0.85 for banded, incorporated; and 0.99 for in-furrow, incorporated.

<sup>b</sup>Back calculation equations for mg a.i./ft<sup>2</sup> which when applied will meet the LOC. BW is body weight.

When applied in bands:

$$y \frac{(\text{mg a.i.})}{1 (\text{ft}^2 \text{ within band})} = \frac{\text{LOC} / (\text{ft}^2) \times \text{LD}_{50} (\text{mg} / \text{kg} - \text{bw} / \text{day}) \times \text{BW} (\text{grams}) \times \frac{1 (\text{kg})}{1,000 (\text{kg})}}{(1 - f_{\text{efficiency}})}$$

When applied as broadcast: the same equation for in bands is used except the units are as mg a.i./ft<sup>2</sup>.

<sup>c</sup>Calculation of lbs a.i./A.

When applied in bands:

$$x \frac{(\text{lbs a.i.})}{1 (\text{A})} = \frac{y \frac{(\text{mg a.i.})}{1 (\text{ft}^2 \text{ within band})} \times \frac{1 (\text{lb})}{453,590 (\text{mg})}}{\left( \frac{43,560 (\text{ft}^2)}{1 (\text{A})} \times z (\text{bandwidth in ft}) \right) \div i (\text{row spacing in ft})}$$

When broadcast:

$$x \frac{(\text{lbs a.i.})}{1 (\text{A})} = y \frac{(\text{mg a.i.})}{1 (\text{ft}^2 \text{ within band})} \times \frac{1 (\text{lb})}{453,590 (\text{mg})} \times \frac{43,560 (\text{ft}^2)}{1 (\text{A})}$$

## **ATTACHMENT 1**

### **July 12, 2001 Memorandum: Revised Fenamiphos Estimated Environmental Concentrations**